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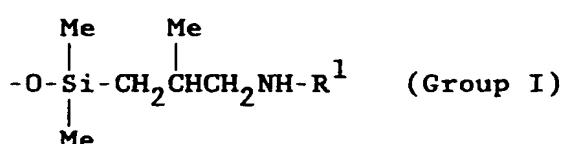
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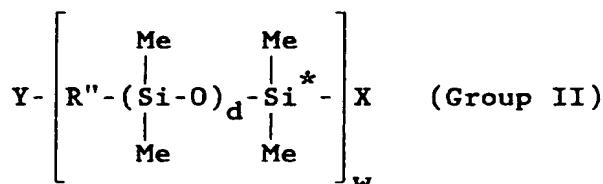
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54) Alkoxy endblocked polydiorganosiloxane and room temperature vulcanizable silicone elastomers made therefrom.

57 An alkoxy endblocked polydiorgansiloxane of the formula  
$$Z-(SiR_2O)_nSiR_2Z$$
 where  $Z$  is

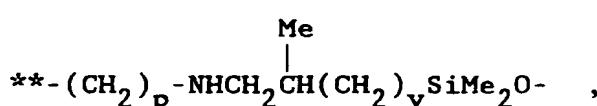


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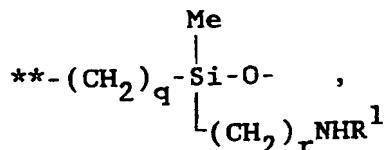
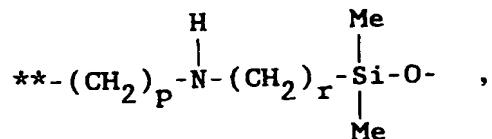


where  $Y$  is

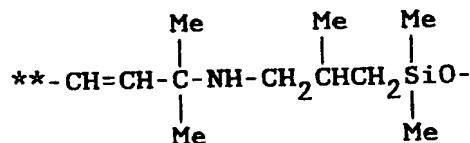
Yin



$$\text{***-}(\text{CH}_2)_q\begin{array}{c} \text{Me} \\ | \\ \text{SiO-} \\ | \\ \text{CH}_2\text{CHCH}_2\text{NHR}^1 \end{array},$$



or



in which a is 0 or 1, d has a value of 1 to 3 inclusive, v is 0 or 1 n has a value of at least 8, p has a value of 3 to 6 inclusive, q has a value of 2 to 6 inclusive, r has a value of 4 to 6 inclusive, w is 0 or 1, Me is methyl radical,  $\text{R}^1$  is an alkyl radical having from 1 to 6 inclusive carbon atoms, each  $\text{R}'$  is a monovalent radical independently selected from the group consisting of hydrocarbon radicals and halogenated hydrocarbon radicals,  $\text{R}'$  is an alkyl radical of 1 to 3 inclusive carbon atoms,  $\text{R}''$  is a divalent hydrocarbon radical selected from the group consisting of  $-(\text{CH}_2)_b-$  and  $-\text{CH}(\text{Me})(\text{CH}_2)_c-$ , b is from 2 to 6 inclusive, c is from 0 to 4 inclusive, the bond at  $**$  is attached to the silicon atom  $\text{Si}^*$ , can be used as the base polymer for making one package room temperature vulcanizable silicone elastomer compositions by combining it with alkoxysilane, titanium catalyst and filler. These RTV's cure rapidly and exhibit adhesion to substrates upon which they are cure.

This invention relates to alkoxy functional polydiorganosiloxanes, a method of their preparation and room temperature vulcanizable silicone elastomers made using the alkoxy functional polydiorganosiloxanes.

One of the silicone sealants is based upon the use of alkoxy endblocked polymers and a titanium catalyst. Such sealants are stable in the absence of moisture, but cure in the presence of moisture to a silicone elastomer. A distinguishing feature of this system over other moisture-curing systems is the absence of acidic or corrosive by-products produced during the curing process.

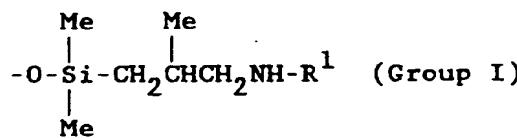
In storage tubes, many moisture curing sealants often exhibit over long storage periods, gradual curing due to reaction with moisture. When use of that sealant is later attempted, the sealant cannot be expelled from the storage tube because it is too viscous or it has completely cured. In contrast, the alkoxy-titanate room temperature vulcanizable (RTV) silicone elastomer compositions gradually lose their ability to cure with time of storage. This is particularly undesirable because the sealant can be expelled from the tube into the desired location for sealing without the user's knowledge that there is anything wrong. It is only after the sealant fails to cure that a problem becomes apparent and by then it is too late as the sealant is already in place. It is then necessary to physically remove all of the old non-curing sealant and replace it with new. This is a very time consuming and expensive process. Because of these failures, it is imperative that a method of producing a non-acid, non-corrosive RTV silicone sealant be developed that would overcome these problems.

There are many patents in the art directed to silicone sealants using alkoxy functional polymers, alkoxy functional crosslinkers and titanate catalysts. See, for example, US-A 3,334,067; US-A 3,383,355; US-A 3,856,839; US-A 3,856,839; US-A 4,438,039; US-A 3,122,522; US-A 3,175,993; US-A 4,731,411; 7S-A 4,579,964 and US-A 4,888,404.

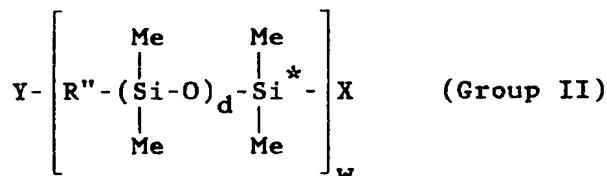
This invention relates to a polydiorganosiloxane comprising an alkoxy endblocked polydiorganosiloxane of the following general formula



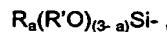
where Z is



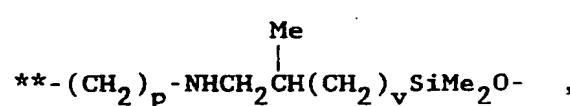
or



where Y is

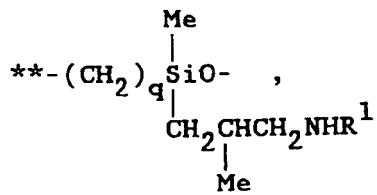


X is



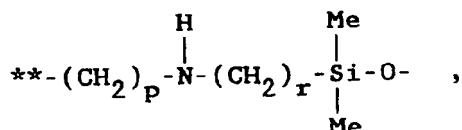
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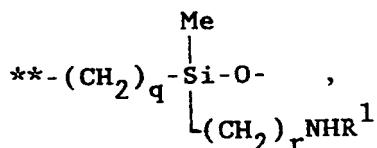
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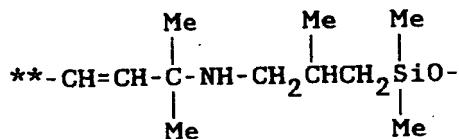


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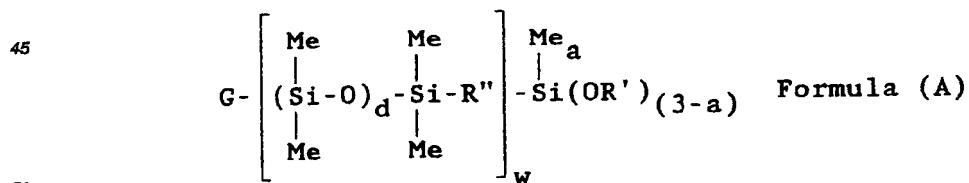
25 or



35 in which a is 0 or 1, d has a value of 1 to 3 inclusive, v is 0 or 1, n has a value of at least 8, p has a value of 3 to 6 inclusive, q has a value of 2 to 6 inclusive, r has a value of 4 to 6 inclusive, w is 0 or 1, Me is methyl radical, R is a monovalent radical selected from the group consisting of hydrocarbon radicals and halogenated hydrocarbon radicals, R<sup>1</sup> is an alkyl radical having from 1 to 6 inclusive carbon atoms, R' is an alkyl radical of 1 to 3 inclusive carbon atoms, R'' is a divalent hydrocarbon radical selected from the group consisting of -(CH<sub>2</sub>)<sub>b</sub>- and -CH(Me)(CH<sub>2</sub>)<sub>c</sub>-; b is from 2 to 6 inclusive, c is from 0 to 4 inclusive and the bond at \*\* is attached to the silicon atom Si\*.

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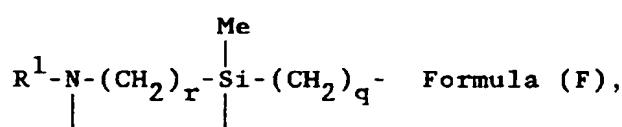
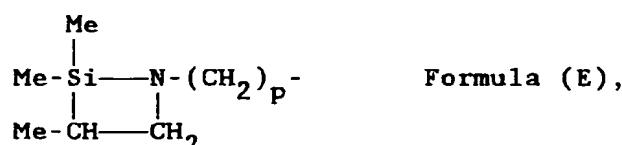
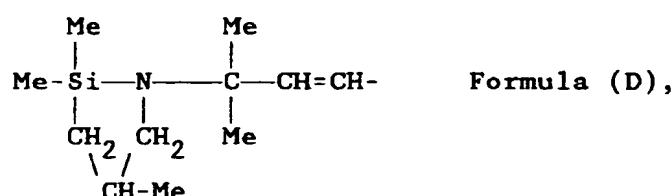
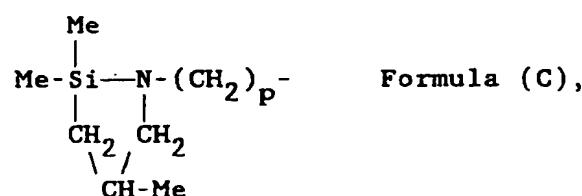
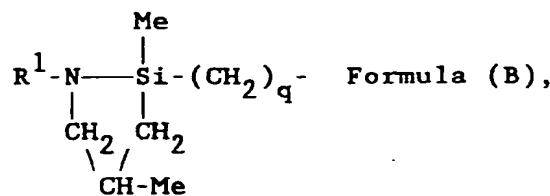
This invention also relates to a method of preparing the alkoxy endblocked polydialkylsiloxanes comprising mixing an azasilacycloalkyl functional alkoxysilane selected from the group consisting of



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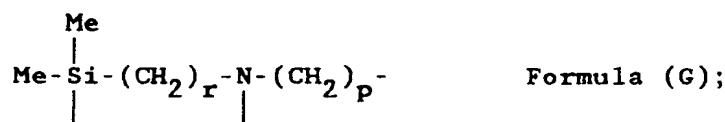
in which G is an azasilacycloalkyl group selected from the group consisting of

55



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and



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in which  $\text{R}^1$  is an alkyl radical of from 1 to 6 inclusive carbon atoms,  $\text{R}'$  is an alkyl radical of from 1 to 3 carbon atoms,  $\text{R}''$  is a divalent hydrocarbon radical selected from the group consisting of  $-(\text{CH}_2)_b-$  and  $-\text{CH}(\text{Me})(\text{CH}_2)_c-$ ,  $b$  is from 2 to 6 inclusive,  $c$  is from 0 to 4 inclusive, Me is methyl,  $a$  is 0 or 1,  $d$  has a value of 1 to 3 inclusive,  $w$  is 0 or 1,  $p$  has a value of 3 to 6 inclusive,  $q$  has a value of 2 to 6 inclusive and  $r$  has a value of 4 to 6 inclusive with a silanol terminated polydiorganosiloxane of the general formula



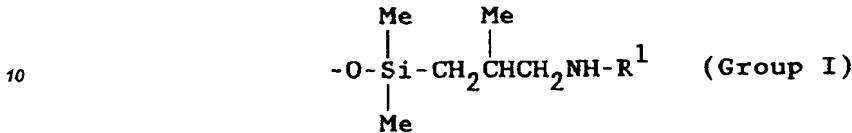
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where each  $\text{R}$  is a monovalent hydrocarbon radical independently selected from the group consisting of hydrocarbon radicals and halogenated hydrocarbon radicals and  $n$  has a value of at least 8.

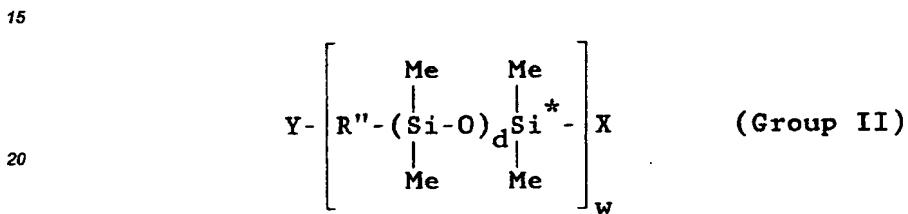
This invention also relates to a one package room temperature vulcanizable silicone elastomer comprising a product which is storage stable in the absence of moisture and curable to an elastomeric product when exposed to moisture and obtained by mixing (A) an alkoxy endblocked polydiorganosiloxane of the following general formula



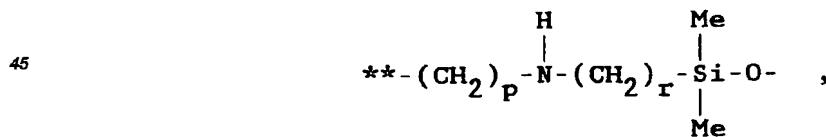
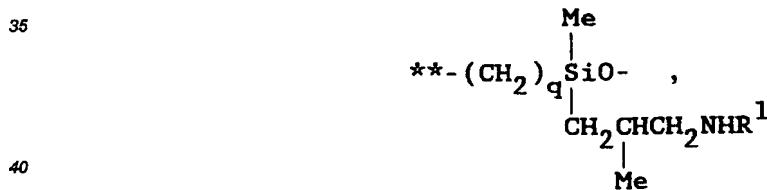
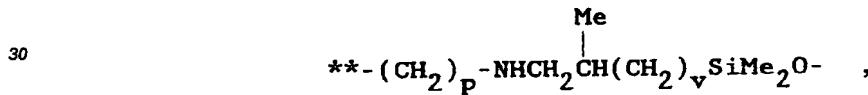
where Z is



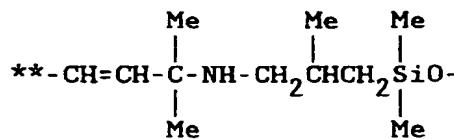
or



where Y is



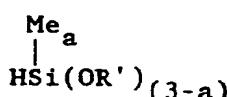
or



in which a is 0 or 1, d has a value of 1 to 3 inclusive, v is 0 or 1, n has a value of at least 8, p has a value of 3 to 6 inclusive, q has a value of 2 to 6 inclusive, r has a value of 4 to 6 inclusive, w is 0 or 1, Me is methyl radical, 10 R<sup>1</sup> is an alkyl radical of from 1 to 6 inclusive carbon atoms, each R is a monovalent radical independently selected from the group consisting of hydrocarbon radicals and halogenated hydrocarbon radicals, R' is an alkyl radical of 1 to 3 inclusive carbon atoms, R'' is a divalent hydrocarbon radical selected from the group consisting of (CH<sub>2</sub>)<sub>b</sub>- and -CH(Me)(CH<sub>2</sub>)<sub>c</sub>-; b is from 2 to 6 inclusive, c is from 0 to 4 inclusive, the bond at \*\* is attached to the silicon atom Si\* and in the alkoxy endblocked polydiorganosiloxane at least one Z is Group II, (B) an 15 alkoxysilane, (C) a titanium catalyst and (D) a filler.

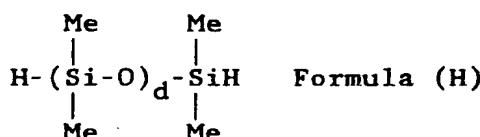
The azasilacycloalkyl functional alkoxysilanes used to make the alkoxy endblocked polydiorganosiloxanes of this invention are selected from those compounds defined by Formula (A).

An azasilacycloalkyl functional alkoxysilane in which w is 0 can be made by reacting, in the presence of a platinum catalyst, an aliphatic unsaturated azasilacyclo-alkane with an alkoxysilane of the formula 20



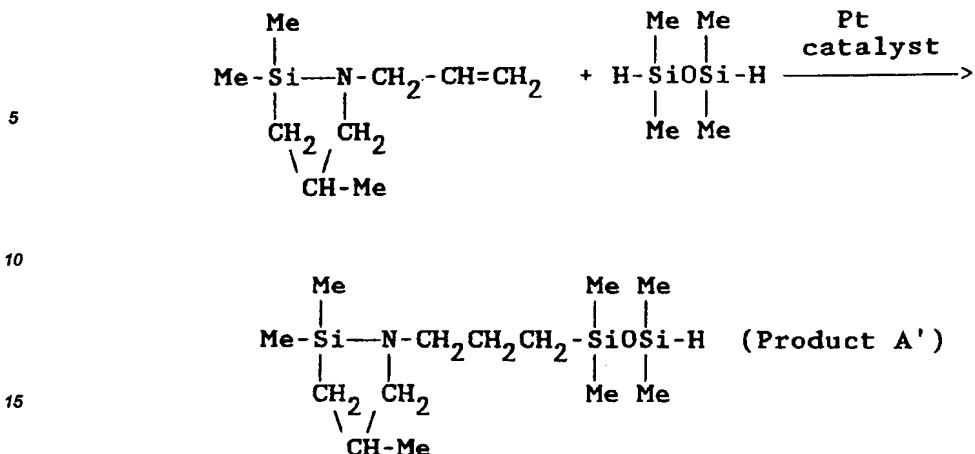
25 in which a is 0 or 1.

The azasilacycloalkyl functional alkoxysilanes where w is 1 can be made by reacting, in the presence of a platinum catalyst, an azasilacycloalkane containing aliphatic unsaturation with a dimethylsiloxane endblocked with hydrogen atoms of the formula 30



where d has a value of 1 to 3 inclusive and which in turn is reacted with an alkoxysilane having aliphatic unsaturation in the presence of a platinum catalyst. Methods of preparing various azasilacycloalkyl functional alkoxysilanes are illustrated in the following description.

An azasilacyclopentyl functional alkoxysilane of Formula (A) where G is Formula (C) and w is 1 can be prepared by reacting a hydrogen ended dimethylsiloxane of Formula (H), such as 1,1,3,3-tetramethyldisiloxane, with 1-(alken-1-yl)-2,2,4-trimethyl-1-aza-2-silacyclopentane in the presence of a platinum catalyst. 1-aza-2-silacyclopentyl functional alkoxysilanes in which p is 3, 4, 5 or 6 can be prepared by using for the 1-(alken-1-yl)-2,2,4-trimethyl-1-aza-2-silacyclopentane, 1-allyl-2,2,4-trimethyl-1-aza-2-silacyclopentane, 1-(buten-1-yl)-2,2,4-trimethyl-1-aza-2-silacyclopentane, 1-(penten-1-yl)-2,2,4-trimethyl-1-aza-2-silacyclopentane, or 1-(hexen-1-yl)-2,2,4-trimethyl-1-aza-2-silacyclopentane. The resulting product is 1-(3-(2,2,4-trimethyl-1-aza-2-silacyclopentyl)propyl)-1,1,3,3-tetramethyldisiloxane when 1,1,3,3-tetramethyldisiloxane is used for the hydrogen dimethylsiloxane of Formula (H). This reaction is preferably carried out by heating under conditions which prevents the ingress of moisture or water into the reaction mixture. In a preferred method, the tetramethyldisiloxane, a small amount of the 1-aza-2-silacyclopentane and platinum catalyst are heated and the remainder of the 1-aza-2-silacyclopentane is then slowly added. The amount of the 1-aza-2-silacyclopentane is such that the moles of the tetramethyldisiloxane exceed the moles of azasilacyclopentane. The product preferably is recovered by distillation. The following equation illustrates the reaction

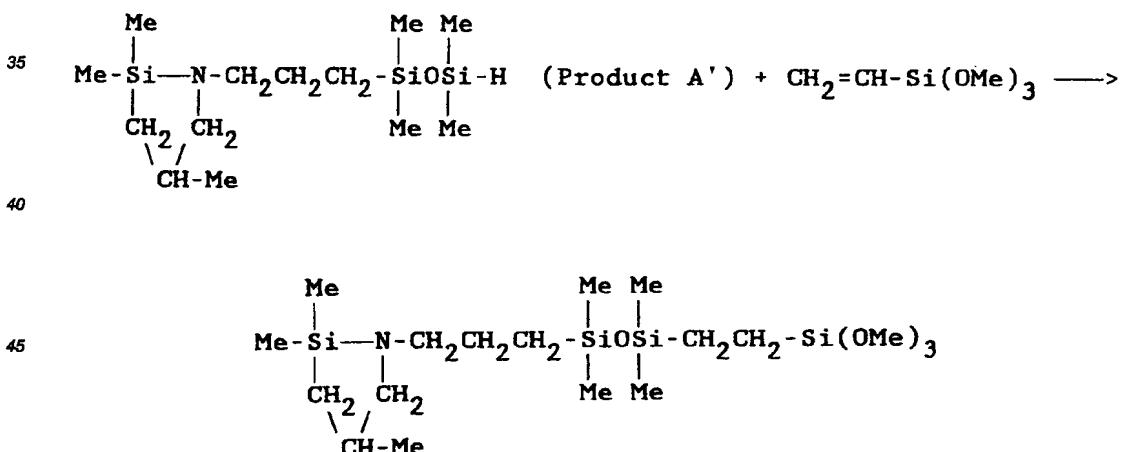


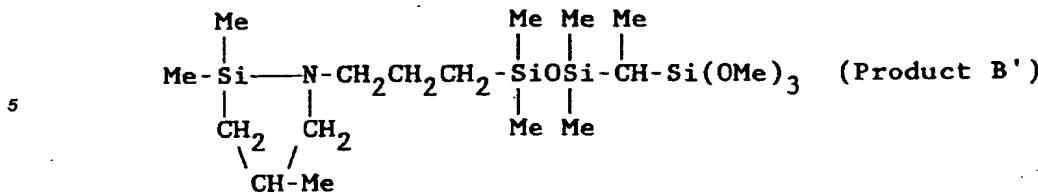
20 Product A' is 1-(3-(2,2,4-trimethyl-1-aza-2-silacyclopentyl)propyl)-1,1,3,3-tetramethyldisiloxane. Product A' is further reacted with either methylalkenyldialkoxysilane or alkenyltrialkoxysilane to make the azasilacyclopentyl functional alkoxy silane Formula (A). Examples of methylalkenyldialkoxysilane include methylvinylidemethoxysilane, methylvinyldiethoxysilane, methylvinyldipropoxysilane, methylvinyldisopropoxysilane, methylallyldimethoxysilane, methylallyldiethoxysilane, methylallyldipropoxysilane, methylbuten-1-yldimethoxysilane, methylpenten-1-yldimethoxysilane, methylpenten-1-yldiethoxysilane, methylhexen-1-yldimethoxysilane and methyl-hexen-1-yldiethoxysilane. Examples of alkenyltrialkoxysilane include vinyltrimethoxysilane, vinyltriethoxysilane, vinyltripropoxysilane, allyltrimethoxysilane, allyltriethoxysilane, allyltripropoxysilane, buten-1-yldimethoxysilane, buten-1-yldiethoxysilane, buten-1-yldipropoxysilane, penten-1-yldimethoxysilane, penten-1-yldiethoxysilane, penten-1-yldipropoxysilane, hexen-1-yldimethoxysilane and hexen-1-yldiethoxysilane. Product A' is combined with an alkoxy silane in the presence of platinum catalyst and preferably heated to cause the alkenyl group of the alkoxy silane to add across the Si-H group of Product A'. This reaction is illustrated by the following equation:

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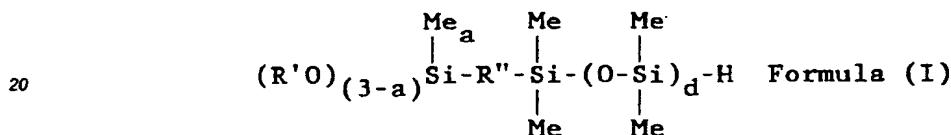
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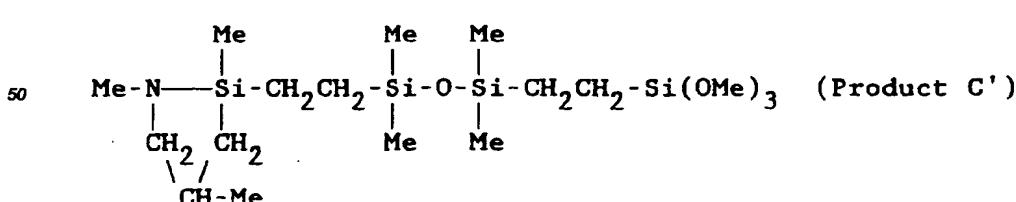
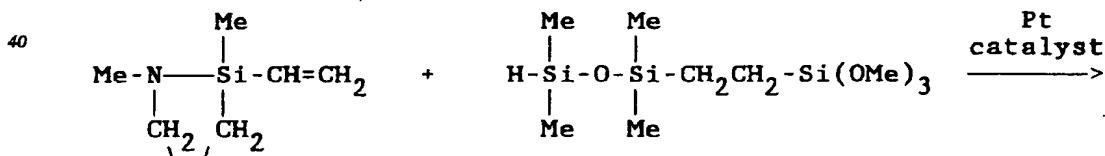


10 Product B' is a mixture of 1-(3-(2,2,4-trimethyl-1-aza-2-silacyclopentyl)propyl)-3-(2-trimethoxysilylethyl)-1,1,3,3-tetramethyldisiloxane and 1-(3-(2,2,4-trimethyl-1-aza-2-silacyclopentyl)propyl)-3-(1-trimethoxysilylethyl)-1,1,3,3-tetramethyldisiloxane. Product B' can be further purified by distillation of the reaction product under reduced pressure.

15 An azasilacyclopentyl functional alkoxy silane of Formula (A) where G is Formula (B) can be prepared by reacting an alkoxy silane having a hydrogen functional end of the formula



25 in which  $a$  is 0 or 1,  $d$  has a value of 1 to 3 inclusive and Me is methyl radical, with 1,2,4-trimethyl-2-alkenyl-1-aza-2-silacyclopentane in the presence of a platinum catalyst. The hydrogen ended alkoxy silanes of Formula (I) can be prepared by reacting an aliphatic unsaturated alkoxy silane with a hydrogen ended dimethylsiloxane of Formula (H) in the presence of a platinum catalyst. The preparation of 1-aza-2-silacyclopentyl functional alkoxy silanes of Formula (A) where G is Formula (B) can be illustrated by 1-( $n^*$ -trimethoxysilylalkyl)-1,1,3,3-tetramethyldisiloxane (Disiloxane A'); 1-(1-methyl- $n^*$ -trimethoxysilylalkyl)-1,1,3,3-tetramethyldisiloxane (Disiloxane B') where  $n^*$  depends upon the particular alkenyl group used; or a mixture of these reacted with 1,2,4-trimethyl-2-vinyl-1-aza-2-silacyclopentane in the presence of a platinum catalyst. This reaction is preferably carried out by heating under conditions which prevent the ingress of moisture or water into the reaction mixture. Disiloxanes A' and B' can be prepared by reacting  $\text{R}'\text{Me}_a\text{Si}(\text{OR})_{(3-a)}$  in which  $\text{R}'$  is an alken-1-yl radical having from 2 to 6 carbon atoms with  $\text{HMe}_2\text{SiOSiMe}_2\text{H}$  in the presence of a platinum catalyst. The alken-1-yl alkoxy silanes are illustrated above. The method for preparing Disiloxanes A' and B' are further described in U.S. Patent No. 4,888,404, which shows the disiloxanes and their preparation. The product is preferably recovered by distillation. The following equation illustrates the reaction



55 Product C' is 1-(2-(1,2,4-trimethyl-1-aza-2-silacyclopentyl)-ethyl)-3-(2-trimethoxysilylethyl)-1,1,3,3-tetramethyldisiloxane. The reaction product which contains Product C' can be further purified by distillation at reduced pressure. In the above reaction the Me (methyl radical) on the ring nitrogen atom is used for illustrative pur-

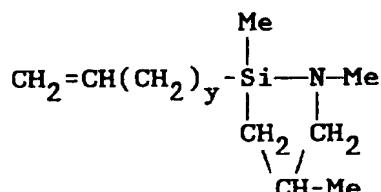
poses as an example of R<sup>1</sup> which can be an alkyl radical selected from methyl, ethyl, propyl, butyl, pentyl and hexyl. In the reactions which follow, in each case where a methyl radical is shown on the ring nitrogen atom, it is used as the preferred alkyl radical for R<sup>1</sup>.

5 The aliphatic unsaturated azasilacyclopentanes used to make the azasilacyclopentyl functional alkoxy-

lanes of Formula

(I)

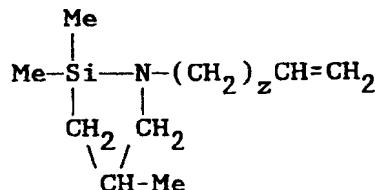
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and

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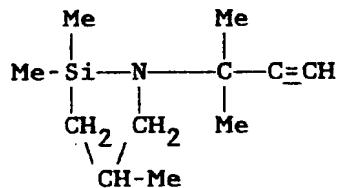


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30 in which y has a value of from 0 to 4 inclusive; z has a value of from 1 to 4 inclusive; and Me is methyl radical. These azasilacyclopentanes are described in our U.S. Patent No. 5,136,064, which shows these azasilacyclopentanes and their preparation.

An azasilacyclopentyl functional alkoxy silanes of Formula (A) where G is Formula (D) can be made by the same method as the preparation for the azasilacyclopentyl functional alkoxy silanes of Formula (A) where G is Formula (C). In these preparations, the aliphatic unsaturated azasilacycloalkane has the formula

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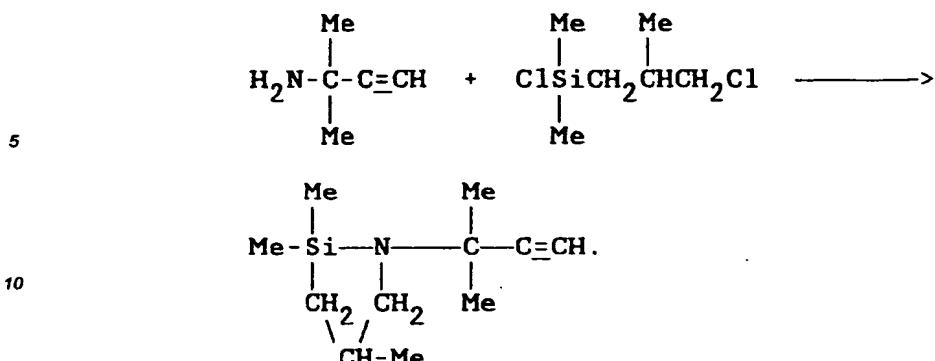


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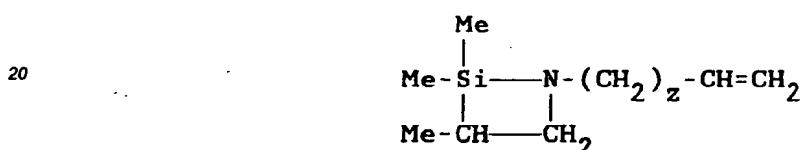
45 This azasilacycloalkane can be prepared by the method described in U.S. Patent No. 5,136,064, where the reaction for the preparation is

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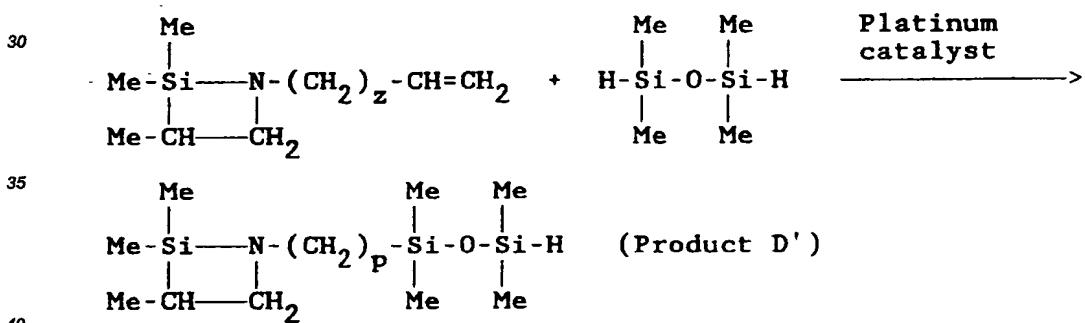
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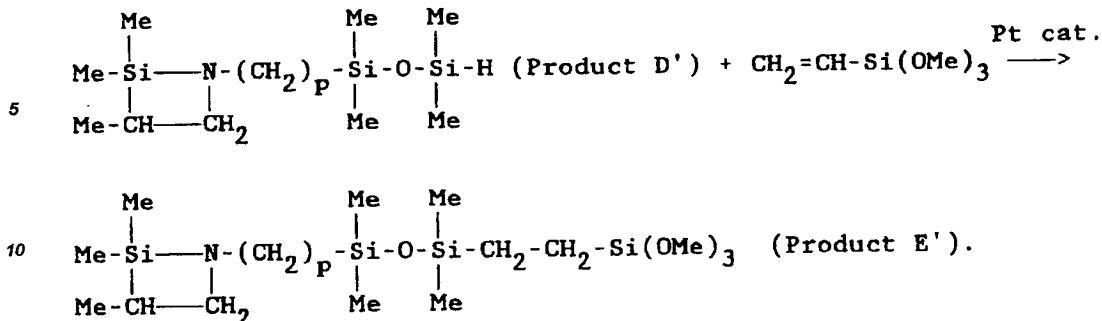
15 An azasilacyclobutyl functional alkoxy silane of Formula (A) where G is Formula (E) can be prepared by reacting a hydrogen ended dimethylsiloxane of Formula (H) with an azasilacyclobutane of the formula



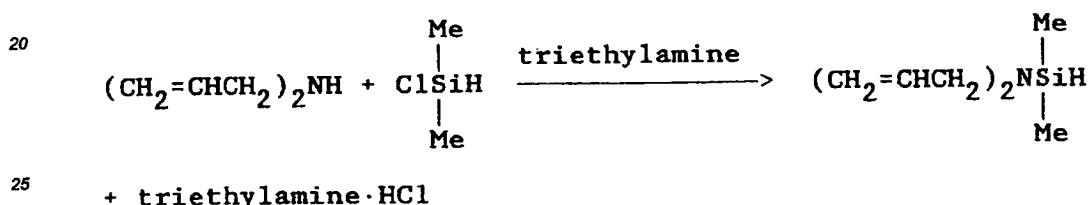
25 where z has a value of 1 to 4 inclusive. This reaction is performed in the presence of a platinum catalyst and the following equation shows the reaction using 1,1,3,3-tetramethyldisiloxane as an example of the hydrogen-ended dimethylsiloxane of Formula (H)



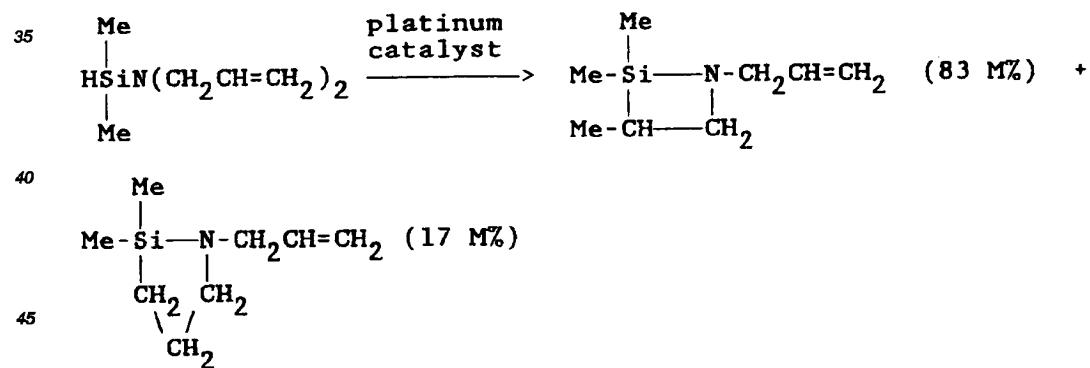
45 Product D' is further reacted with either methylalkenyldialkoxysilane or alkenyltrialkoxysilane to make the azasilacyclobutyl functional alkoxy silane Formula (A) where G is Formula (E). Examples of other alkoxy silanes which can be used are described above. Product D' is combined with an alkoxy silane in the presence of platinum catalyst and preferably heated to cause the alkenyl group of the alkoxy silane to add across the Si-H group of Product D'. This reaction is illustrated by the following equation:



15 The preparation of an azasilacyclobutanes can be illustrated by the following: Diallylamine was reacted with chlorodimethylsilane in heptane in the presence of triethylamine to give diallylaminodimethylsilane per the following equation

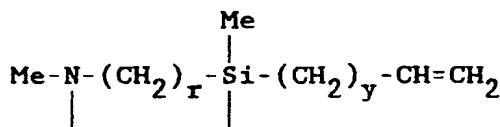


30 The silane product was obtained by ambient pressure distillation after removal of triethylamine hydrochloride by filtration. 1-allyl-2,2,3-trimethyl-1-aza-2-silacyclobutane was made by intramolecular hydrosilation of the di-allyldimethylsilane. This reaction was carried out at 80°C. in the presence of  $\text{PtCl}_2(\text{PPh}_3)_2$  in benzene. The starting material was consumed in four hours to give a product mixture of 83 mole percent of the azasilacyclobutane and 17 mole percent of azasilacyclopentane as illustrated by the following equation



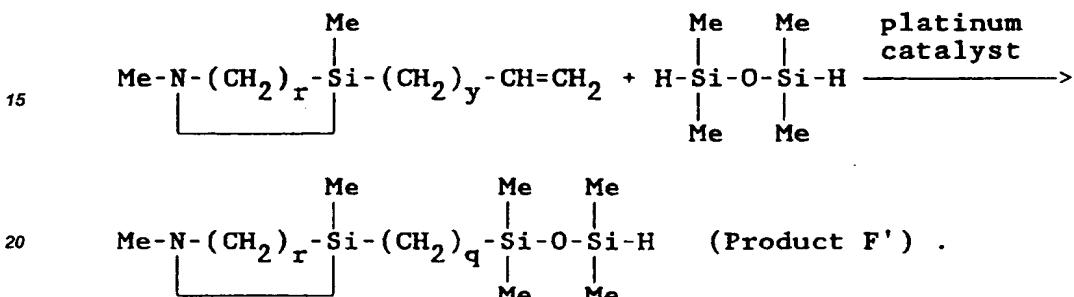
50 Total yield of product was 77 weight percent. The azasilacyclobutane can then be reacted with 1,1,3,3-tetramethyldisiloxane in the presence of a platinum catalyst. The resultant product can in turn be reacted with an alkoxysilane having aliphatic unsaturation as described above to make an azasilacyclobutyl functional alkoxysilane of Formula (A).

An azasilacycloalkyl functional alkoxy silane of Formula (A) where G is Formula (F) can be prepared by reacting a hydrogen ended dimethylsiloxane of Formula (H) with an azasilacycloalkane of the formula



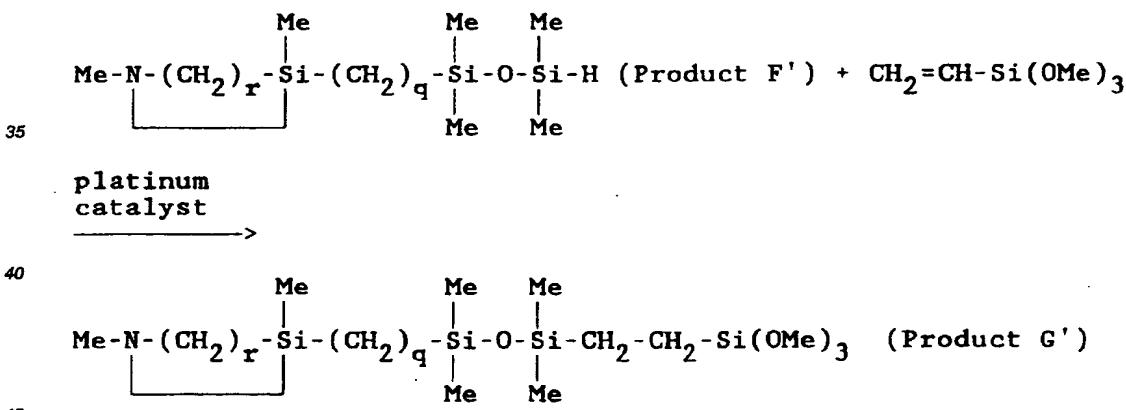
where  $y$  has a value of 0 to 4 inclusive and  $r$  has a value of 4 to 6 inclusive. This reaction is done in the presence of a platinum catalyst and the following equation shows the reaction using 1,1,3,3-tetramethyldisiloxane as an example of a hydrogen ended dimethylsiloxane of Formula (H)

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25 Product F' is further reacted with either methylalkenyl dialkoxy silane or alkenyltrialkoxy silane to make the azasilacycloalkyl functional alkoxy silane Formula (A) where G is Formula (F). Examples of other alkoxy silanes which can be used are described above. Product F' is combined with an alkoxy silane in the presence of platinum catalyst and preferably heated to cause the alkenyl group of the alkoxy silane to add across the Si-H group of Product F'. This reaction is illustrated by the following equation:

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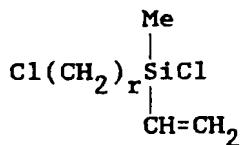


An azasilacycloalkane used to provide the functionality of Formula (F), 2-vinyl-1,2-dimethyl-1-aza-2-silacycloalkane, can be made by reacting

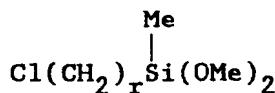
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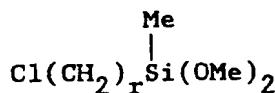
where  $r$  has a value of 4 to 6 inclusive, with methylamine using the procedure described in U.S. Patent No. 3,146,250, which shows a method of preparation for azasilacycloalkanes. The chlorosilane of the formula



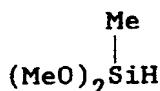
can be made by reacting



15 with vinyl magnesium bromide, followed by reaction with acetyl chloride in the presence of ferric trichloride catalyst. The methoxysilane of the formula

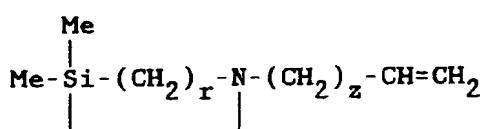


can be made by reacting



30 with  $\text{CH}_2=\text{CH}-(\text{CH}_2)_{(r-2)}\text{Cl}$  in the presence of a platinum catalyst. Other reactions are described in an article by Speier et al, in the Journal of Organic Chemistry, vol. 36, pages 3120-3126, (1971), entitled "Syntheses of (3-Aminoalkyl)silicon Compounds."

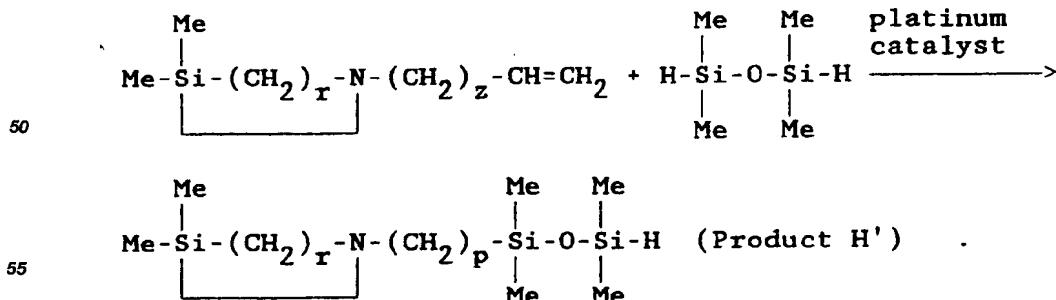
An azasilacycloalkyl functional alkoxysilane of Formula (A) where G is Formula (G) can be prepared by reacting a hydrogen-ended dimethylsiloxane of Formula (H) with an azasilacycloalkane of the formula



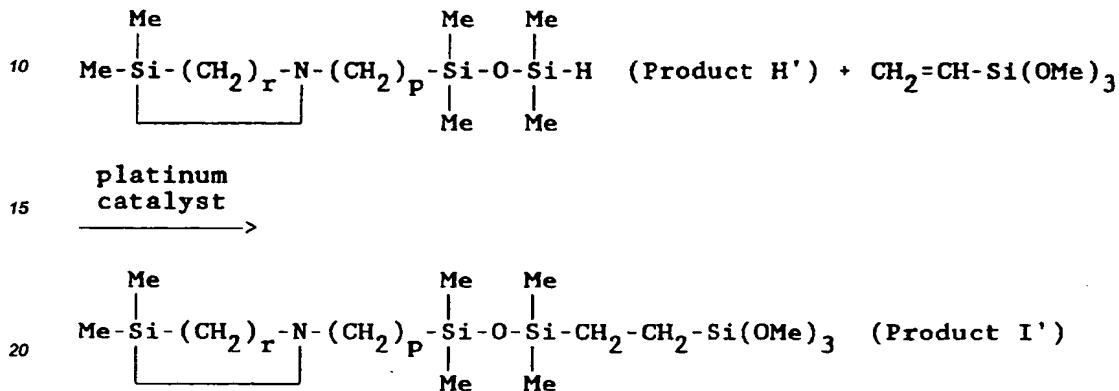
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where  $z$  has a value of 1 to 4 inclusive. This reaction is done in the presence of a platinum catalyst and the following equation shows the reaction using 1,1,3,3-tetramethyldisiloxane as an example of a hydrogen ended dimethylsiloxane of Formula (H)

45



Product H' is further reacted with either methylalkenyldialkoxysilane or alkenyltrialkoxysilane to make the azasilacycloalkyl functional alkoxysilane Formula (A) where G is Formula (G). Examples of other alkoxysilanes which can be used are described above. Product H' is combined with an alkoxysilane in the presence of platinum catalyst and preferably heated to cause the alkenyl group of the alkoxysilane to add across the Si-H group of Product H'. This reaction is illustrated by the following equation:



25 The 1-allyl-2,2-dimethyl-1-aza-2-silacycloalkanes can be made by reacting



35 with  $\text{CH}_2=\text{CHCH}_2\text{NH}_2$  using a procedure described in U.S. Patent No. 3,146,250. The chlorosilane of the formula



45 can be made by reacting



50 with  $\text{CH}_2=\text{CH}(\text{CH}_2)_{(r-2)}\text{Cl}$  in the presence of a platinum catalyst.

The olefinic unsaturation of the 1-aza-2-silacyclopentane reacts with the Si-H group of the tetramethyl-disiloxane in the presence of a platinum catalyst. This reaction is termed an "addition reaction" or a "hydrosilylation reaction" where the olefinic bond reacts with the silicon-bonded hydrogen such that the Si-H adds across the double bond. Platinum catalysts are well known in the art for catalyzing this reaction. These platinum catalysts include the chloroplatinic acid described in U.S. Patent No. 2,823,218; complexes of chloroplatinic acid with low molecular weight vinyl-containing polydiorganosiloxanes, such as syn-divinyltetramethylsiloxane described in U.S. Patent No. 3,419,593; alkene complexes described in U.S. Patent No. 3,159,601 and U.S. Patent No. 3,159,662; the platinum acetylacetone described in U.S. Patent No. 3,723,497; the platinum

alcoholates described in U.S. Patent No. 3,220,972; and in other patents which describe various types of platinum catalysts.

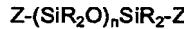
The alkoxy endblocked polydiorganosiloxanes of this invention are prepared by mixing the azasilacycloalkyl functional alkoxy silanes as defined above with a silanol terminated polydiorganosiloxane of the general formula



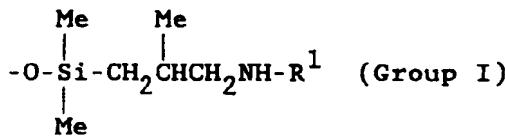
where each R is a monovalent radical independently selected from the group consisting of hydrocarbon radicals and halogenated hydrocarbon radicals and  $n$  has a value of at least 8. This reaction is rapid and goes to completion at room temperature without requiring a catalyst. This reaction should take place under conditions which prevent the ingress of moisture or water into the reaction mixture. The silanol terminated polydiorganosiloxanes are well known in the art and include those in which R is a monovalent hydrocarbon radical such as an alkyl radical, preferably from 1 to 6 carbon atoms, such as methyl, ethyl, propyl, isopropyl, butyl, isobutyl, tertiary butyl, pentyl and hexyl; an aryl radical such as phenyl, tolyl and xylyl; and a monovalent halogenated hydrocarbon radical such as 3,3,3-trifluoropropyl and gamma-chloropropyl. The silanol terminated polydiorganosiloxanes are preferably silanol terminated polydialkylsiloxanes particularly those in which R is methyl radical and  $n$  has an average value of from 50 to 1,000. One advantage of this method is that it can be done continuously. The reaction between the silicon-bonded hydroxyl and the azasilacyclopentane group is fast enough that the alkoxy endblocked polydiorganosiloxanes of the present invention can be made continuously.

Alkoxy endblocked polydiorganosiloxanes of this invention can also be prepared in which one end of the polymer is Group I and one end is Group II. Such alkoxy endblocked polydiorganosiloxanes are prepared as described above by including with the azasilacyclopentyl functional alkoxy silanes of Formula (A), 1,2,2,4-tetramethyl-1-aza-2-silacyclopentane. The azasilacycloalkyl functional alkoxy silanes produce Group II ends and the 1,2,2,4-tetramethyl-1-aza-2-silacyclopentane produces Group I ends. Group I ends do not become cross-linkages during ordinary exposure to moisture at room temperature and in an RTV composition. When both the 1,2,2,4-tetramethyl-1-aza-2-silacyclopentane and aza-silacyclopentyl functional alkoxy silanes are present in the reaction with hydroxyl-endblocked polydiorganosiloxane, the results are a statistical mixture of three kinds of polymers. One type of polydiorganosiloxane is alkoxy endblocked polydiorganosiloxanes with Group II on both ends (Type 1). Another type of polydiorganosiloxane is alkoxy endblocked polydiorganosiloxane with Group I on one end and Group II on the other end (Type 2). The third type of polydiorganosiloxane is a polydiorganosiloxane in which both ends are Group I (Type 3). This third type does not contain silicon-bonded alkoxy groups and therefore would not enter into a crosslinking reaction when exposed to moisture. The reaction product when hydroxyl-endblocked polydiorganosiloxane, 1,2,2,4-tetramethyl-1-aza-2-silacyclopentane and azasilacyclopentyl functional alkoxy silanes are combined, is a mixture of the three types of polydiorganosiloxanes. The greater the amount of 1,2,2,4-tetra-methyl-1-aza-2-silacyclopentane present in the reaction mixture, the higher the concentration of Type 3 polydiorganosiloxane. For this reason (because Type 3 polydiorganosiloxanes are unreactive), the amount of 1,2,2,4-tetramethyl-1-aza-2-silacyclopentane used is that amount which is insufficient to produce polydiorganosiloxane with greater than 50% of the ends as Group I when the alkoxy endblocked polydiorganosiloxanes of this invention are to be used in the preparation of RTV compositions. The reaction products in which less than 30% of the ends are Group I are preferred for lowering the modulus of cured products from exposing RTV compositions to moisture. The higher the content of Group I ends in the polydiorganosiloxane mixture, the lower the crosslink density of cured RTV compositions prepared therefrom and the lower the modulus (other ingredients being equal).

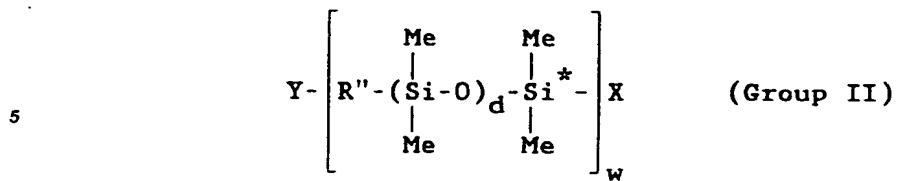
The room temperature vulcanizable silicone elastomeric sealants prepared by using the alkoxy endblocked polydiorganosiloxanes of this invention cure rapidly and have excellent shelf life. The sealant is made from a mixture of (A) alkoxy endblocked polydiorganosiloxanes having the following general formula



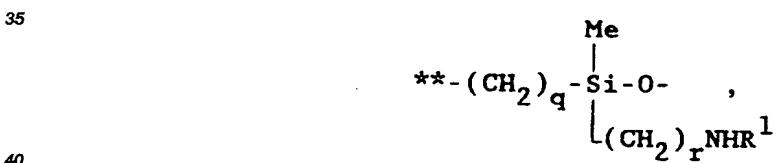
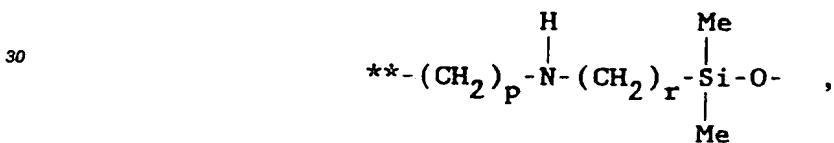
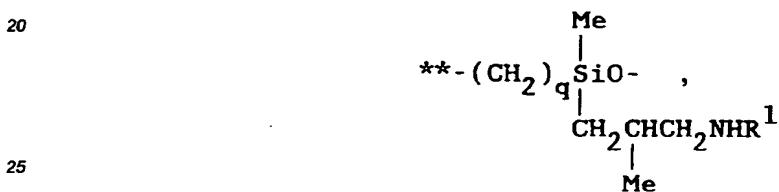
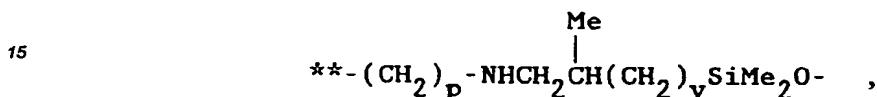
where Z is



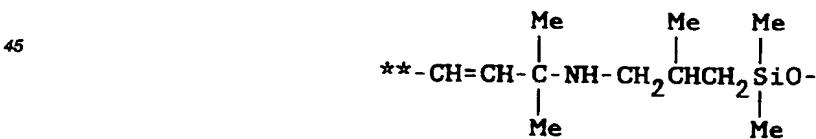
55  
or



10 where  $Y$  is  
 $R_a(R'O)_{(3-a)}Si^-$ ,  
 $X$  is



or

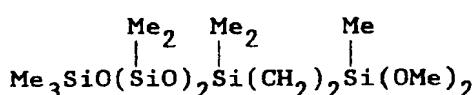


50 in which  $a$  is 0 or 1,  $d$  has a value of 1 to 3 inclusive,  $v$  is 0 or 1,  $n$  has a value of at least 8,  $p$  has a value of 3 to 6 inclusive,  $q$  has a value of 2 to 6 inclusive,  $r$  has a value of 4 to 6 inclusive,  $w$  is 0 or 1,  $Me$  is methyl radical,  $R^1$  is an alkyl radical having from 1 to 6 inclusive carbon atoms, each  $R$  is a monovalent radical independently selected from the group consisting of hydrocarbon radicals and halogenated hydrocarbon radicals,  $R'$  is an alkyl radical of 1 to 3 inclusive carbon atoms,  $R''$  is a divalent hydrocarbon radical selected from the group consisting of  $-(CH_2)_b-$  and  $-CH(Me)(CH_2)_c-$ ,  $b$  is from 2 to 6 inclusive,  $c$  is from 0 to 4 inclusive, the bond at  $**$  is attached to the silicon atom  $Si^*$  and in the alkoxy endblocked polydiorganosiloxane at least one  $Z$  is Group II, (B) an alkoxy silane, (C) a titanium catalyst and (D) a filler.

These silicone sealants do not lose their ability to cure upon exposure to moisture after the sealant is stored

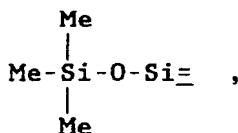
for a long period of time in the absence of moisture. As was noted before, it has been found that silicone elastomer sealants of the type based upon alkoxy endblocked polydiorganosiloxanes and titanate catalyst lose their ability to cure upon shelf aging. A study was undertaken to determine the cause of the loss of curability in the hope that a solution to the problem could then be determined. A model compound having  $-\text{Si}(\text{Me})(\text{OMe})_2$  ends 5 was reacted with tetrabutyltitanate (TBT) at 70°C. and the reaction products were analyzed. Me represents methyl radical and Vi represents vinyl radical. It was found that there was relatively large amounts of  $\text{Me}_2\text{Si}(\text{OR})_2$  where R was either methyl or butyl radicals. Further studies showed that this difunctional product could only be produced by degradation of the dialkoxy functional polymer ends with the production of mono-10 alkoxy ended polymer, thus destroying the model compound. It was known that a monoalkoxy ended polymer would not produce a cure in this type of cure system. Further testing showed that the reaction that was taking place was a reaction of the titanate catalyst with the end siloxy group of the polymer, removing it from the polymer and leaving an alkoxy group in its place. A method of preventing this reaction between the titanate and the end siloxy group of the polymer was then sought. A second model compound was prepared with the formula

15



20 and this compound was combined with tetrabutyltitanate and heated at 70°C. for 70 days. At the end of that time there was no  $\text{Me}_2\text{Si}(\text{OR})_2$ , showing that this could be a solution to the problem, since this model compound remained intact and no degradation had occurred as in the first case. These tests demonstrated that when the terminal silicon atom in the polymer has three carbon atoms attached, as on the one end of this model compound,

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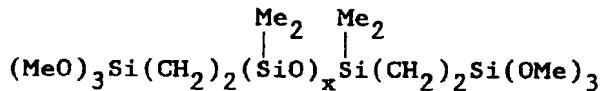


30

or when the oxygen atom between the penultimate silicon atom and the terminal silicon atom is replaced by a carbon linkage, as at the other end of this model compound, there is no reaction with the titanium catalyst, other than alkoxy exchanges.

35 This finding was then evaluated in a curable composition in the following manner. A dimethylhydrogensiloxy endblocked polydimethylsiloxane was mixed with an excess of vinyltrimethoxysilane in the presence of  $\text{H}_2\text{PtCl}_6$  and heated overnight at 100°C. in the absence of moisture. The product was a polymer of the formula

40



45 This polymer was combined with tetrabutyltitanate and heated at 70°C. for 8 weeks. At various times during this heating period, a sample of the polymer was deposited in an aluminum dish and exposed to the moisture in the air to evaluate the cure properties. All samples produced a tight, dry cure in 24 hours at room temperature. This showed that this might be a solution to the shelf stability problem. Further work established that silicone sealants could be produced using the method of this invention which had improved shelf life when compared to similar compositions not made with the alkylsilethylene ended polymer.

50 Alkoxysilane crosslinkers (B) are well known in the art. For example, those alkoxysilanes of the formula  $\text{R}_x\text{Si}(\text{OR}')_{(4-x)}$  where R is methyl or phenyl, R' is methyl, ethyl or propyl and x is 0 or 1 are added as a moisture scavenger and as a modulus control agent. Preferred are the silanes in which there are three alkoxy groups present, such as methyltrimethoxysilane. The amount of crosslinker preferably is from 0.35 to 9.0 parts by weight per 100 parts by weight of alkoxy endblocked polydiorganosiloxane, with from 2 to 8 parts most preferred. It is possible to produce useful sealants without using a crosslinker when the polydiorganosiloxane (A) is present because of the functionality of the polymer itself, but from a practical viewpoint, the crosslinker is preferred because it contributes to the excellent shelf life of the sealant. It is also useful in controlling the degree of crosslinking in the cured elastomeric sealant; whereby higher concentrations of the crosslinker result in a

harder, lower elongation elastomer.

The sealant compositions of this invention are cured through the use of a titanium catalyst (C). The titanium catalyst can be any of those known to be useful for catalyzing the moisture induced reaction of alkoxy containing siloxanes or silanes. Preferred are a titanium catalyst such as titanium esters, including tetrabutyltitanate, tetraisopropyltitanate, tetra-2-ethylhexyltitanate, tetraphenyltitanate and triethanolaminetitanate; organosiloxytitanium compounds such as those described in U.S. Patent No. 3,294,739; and beta-dicarbonyl titanium compounds such as those described in U.S. Patent No. 3,334,067. Preferred catalysts include tetrabutyltitanate, tetraisopropyltitanate and bis(acetoacetyl)diisopropoxy titanium (IV). The amount of catalyst is from 0.2 to 6.0 parts by weight per 100 parts by weight of alkoxy endblocked polydiorganosiloxane (A). Preferred concentrations are from 0.5 to 3.0 parts by weight.

The RTV silicone sealant compositions of this invention contain a filler as one of the ingredients. These fillers are well known in the industry. They are added to the mixture to provide reinforcement of the polymer, to provide control of the flow characteristics of the sealant before curing, to control the physical properties of the sealant after curing and to extend the bulk of the sealant to reduce the cost of the ingredients, as well as, to provide other desired characteristics such as opacity. Reinforcing fillers such as fume silica, precipitated silica and diatomaceous earth are used to give the highest physical strengths to the sealants. Reinforcing fillers are generally recognized as being very fine particles having a surface area from about 50 to 700 m<sup>2</sup>/g. These fillers may be untreated fillers or treated fillers where the treatment is used to modify the filler surface. Extending fillers such as titanium dioxide, zirconium silicate, calcium carbonate, iron oxide, ground quartz and carbon black are commonly used. The amounts of filler used can obviously be varied within wide limits in accordance with the intended use. For example, in some cases the sealant could be used with no filler, but it would have very low physical properties. Reinforcing fillers are commonly used in amounts from 5 to 50 parts by weight to give the highest physical properties, such as tensile strength. Extending fillers are finely ground in that the average particle size is in the range of from 1 to 10 micrometres. Extending fillers are used in amounts as high as 500 parts by weight per 100 parts by weight of the alkoxyendblocked polydiorganosiloxane of (A).

Other ingredients which are commonly used in RTV silicone sealant compositions can also be used in this invention such as colorants, flame retardant additives, plasticizers, compression set additives and modulus control additives.

The RTV silicone sealant compositions are preferably made by mixing the alkoxy endblocked polydiorganosiloxane of (A) with filler (D) until a uniform mixture is obtained. The mixing process can be carried out with a low shear mixer or stirrer in the case of the extending fillers or with a high shear mixer such as a dough mixer or 3-roll mill in the case of the reinforcing fillers. After (A) and (D) are mixed, it is desirable to place them in a container and centrifuge them to remove any entrapped air (deairing). A deaired mixture of alkoxy silane crosslinker (B) and titanium catalyst (C) are added in the absence of moisture to the mixture of (A) and (D). They are thoroughly stirred to give a uniform mixture. The uniform mixture is then preferably deaired, aged 24 hours and again deaired by exposing the mixture to a vacuum to remove any volatiles from the mixture. The mixture is then sealed into storage containers, sealant tubes for example, to store it until it is to be used.

When the RTV silicone sealant composition is exposed to moisture, it cures to give an elastomeric product. The composition is useful as a sealant for filling spaces and gaps which may be found in buildings. These RTV silicone sealants of this invention exhibit improved adhesion to the substrates on which it is cured.

The following syntheses and examples are included for illustrative purposes only and should not be construed as limiting the invention, which is set forth in the appended claims. All parts are parts by weight, viscosities were measured at 25°C. unless otherwise indicated, Me = methyl radical and Vi = vinyl radical.

#### SYNTHESIS 1

2,2,4-trimethyl-1-allyl-1-aza-2-silacyclopentane was prepared as follows. Chlorodimethyl(3-chloro-2-methylpropyl) silane (100 g.) was slowly added to 211.73 g. of undistilled allyl amine resulting in an exothermic reaction. This reaction mixture was stirred at room temperature for 15 hours, heated to reflux at atmospheric pressure for 72 hours and heated to 120°C. under about 344.7 kPa (50 psi) gage pressure for 16 hours. The following GC-MS ratios shown in Table I exemplify the reaction progression and the spectra observed.

TABLE I

	RETENTION TIME, MIN	15 HOURS 20°C	24 HOURS REFLUX	72 HOURS REFLUX	16 HOURS 120°C	COMPOUND
5	2.70	0.0	3.9	21.3	71.9	E
	2.82	0.0	1.0	1.1	0.9	F
10	3.20	50.4	11.0	4.1	0.0	G
	5.19	29.5	63.0	40.2	0.0	H
15	8.46	20.0	8.8	8.1	2.4	I
	9.58	0.0	9.3	10.1	6.1	J
	10.58	0.0	3.1	15.1	18.7	K

Compound E was 2,2,4-trimethyl-1-allyl-1-aza-2-silacyclo-pentane and the spectra was 169 (819), M<sup>+</sup>; 154 (1326), M<sup>+</sup>-CH<sub>3</sub>; 142 (1074), M<sup>+</sup>-Vi; 127 (375), M<sup>+</sup>-C<sub>3</sub>H<sub>6</sub>; 126 (354), M<sup>+</sup>-C<sub>3</sub>H<sub>7</sub>; 100 (784), M-69; 86 (8734), Me<sub>2</sub>SiN=CH<sub>2</sub><sup>+</sup>; 59 (10000), Me<sub>2</sub>SiH<sup>+</sup>. Compound F was not determined.

Compound G was chlorodimethyl(3-chloro-2-methylpropyl)silane and the spectra was 184 (0), M<sup>+</sup>; 169 (233), M<sup>+</sup>-Me; 137 (292), M<sup>+</sup>-47; 113 and 115 (2459 and 1991), Cl<sub>2</sub>MeSi<sup>+</sup>; 93 (9786), ClMe<sub>2</sub>Si<sup>+</sup>; 56 (10000), C<sub>4</sub>H<sub>8</sub>.

Compound H was allylaminodimethyl(3-chloro-2-methylpropyl)silane and the spectra was 205 (10), M<sup>+</sup>; 190 (79), M<sup>+</sup>-Me; 170 (153), M<sup>+</sup>-Cl; 149 (618), M<sup>+</sup>-C<sub>4</sub>H<sub>8</sub>; 134 and 136 (1263 and 508), M<sup>+</sup>-CH<sub>3</sub>-C<sub>4</sub>H<sub>8</sub>; 120 and 122 (1250 and 625), unassigned; 114 (10000), CH<sub>2</sub>=CHCH<sub>2</sub>NHSiMe<sub>2</sub><sup>+</sup>; 98 (4709), unassigned; 93 and 95 (4999 and 1948), ClMe<sub>2</sub>Si<sup>+</sup>.

Compound I was 1,1,3,3-tetramethyl-1,3-bis(3-chloro-2-methylpropyl)disiloxane and the spectra was 314 (0), M<sup>+</sup>; 187 and 189 (2045 and 1291), ClMe<sub>2</sub>SiOSiMeCl<sup>+</sup>; 167 and 169 (10000 and 3897), ClMe<sub>2</sub>SiOSiMe<sub>2</sub><sup>+</sup>.

Compound J was 1,1,3,3-tetramethyl-1-(3-chloro-2-methylpropyl)-1-(3-allylamo-2-methylpropyl)disiloxane and the spectra was 335 (0), M<sup>+</sup>; 320 (52), M<sup>+</sup>-Me; 167 and 169 (1216 and 463), ClMe<sub>2</sub>SiOSiMe<sub>2</sub><sup>+</sup>; 70 (10000), CH<sub>2</sub>=CHCH<sub>2</sub>NH=CH<sub>2</sub><sup>+</sup>.

Compound K was 1,1,3,3-tetramethyl-1,3-bis(3-allylamo-2-methylpropyl)disiloxane and the spectra was 356 (0), M<sup>+</sup>; 170 (1017), CH<sub>2</sub>=CHCH<sub>2</sub>NHCH<sub>2</sub>CH(CH<sub>3</sub>)CH<sub>2</sub>SiMe<sub>2</sub><sup>+</sup>; 169 (1177), peak 170-H; 70 (10000), CH<sub>2</sub>=CHCH<sub>2</sub>NH=CH<sub>2</sub><sup>+</sup>.

Upon cooling the product of the reaction, a two phase system resulted. The upper phase weighed 111.85 g and contained most of the product 2,2,4-trimethyl-1-allyl-1-aza-2-silacyclopentane. The lower phase weighed 177.12 g and was an amber viscous liquid. This lower phase was concentrated at atmospheric pressure with a pot temperature of 120°C. to 122 g. Another 4.0 g of the upper phase was separated upon cooling. The combined product phases were distilled under vacuum. After a slow evolution of allylamine, the product codistilled with an ammonium salt at 78°C. and 4.0 kPa (30 mmHg). Filtration gave 51.63 g (56% yield) of essentially pure 2,2,4-trimethyl-1-allyl-1-aza-2-silacyclopentane. The <sup>13</sup>C NMR was: 138.13, vinyl; 114.39, vinyl; 58.98, allyl CH<sub>2</sub>; 50.31, ring CH<sub>2</sub>N; 31.88, CH; 21.94 and 21.50, SiCH<sub>2</sub> and C-Me; 0.22 and -0.76, SiMe. The <sup>29</sup>Si NMR spectra had one peak at 15.56 ppm relative to tetramethylsilane.

#### SYNTHESIS 2

1,2,4-trimethyl-2-vinyl-1-aza-2-silacyclopentane was prepared as follows. To a solution of 50.0 g. of dimethoxymethyl(3-chloro-2-methylpropyl)silane in 250 ml of diethyl ether contained in a three-necked, 1 L (liter) round-bottom flask fitted with a mechanical stirrer, nitrogen inlet and addition funnel was added over one hour, a solution of 290 ml of 1 M (molar) vinyl magnesium bromide in tetrahydrofuran (THF). The reaction was allowed to stir overnight under a nitrogen atmosphere at room temperature and the slightly yellowish liquid was decanted from the solids. The solvents were removed at 40°C. and 1.2 kPa (9 mmHg) to yield 68.09 g of a yellow liquid with considerable amounts of solids. To this was added 50 ml of benzene and the salts were removed by filtration through a coarse glass frit funnel. The collected solids were washed with two 30 ml portions of benzene. The combined organic fractions were stripped at 50°C. and 1.2 kPa (9 mmHg) to yield 40.19 g of liquid with a small amount of salts. The results of gas chromatography-mass spectroscopy (GC-MS) showed the following composition of the liquid:

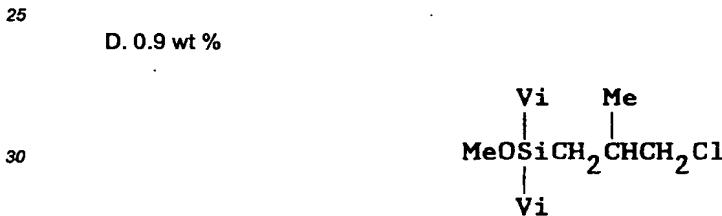
A. 1.9 wt %



B. 92.9 wt %



C. 3.3 wt %



3.1 wt % of 9 unidentified impurites at an order of magnitude lower level.

35 The mass spectra were used to identify these compounds and the results were:  
 For B compound: 192, not observed,  $\text{M}^+$ ; 165(10), M-Vi; 137 (10), NA; 121(210),  $(\text{MeO})\text{ViClSi}^+$ ; 109(230),  $(\text{MeO})\text{MeClSi}^+$ ; 101(780),  $(\text{MeO})\text{MeViSi}^+$ ; 56(1000),  $\text{C}_4\text{H}_8^+$  where data are presented as charge (m/e), (relative intensity).

For C compound: 188, not observed,  $\text{M}^+$ ; 161(8), M-Vi; 117 (280),  $\text{Vi}_2\text{ClSi}^+$ ; 105(284),  $\text{MeViSi}^+$ ; 97(489),  $\text{Vi}_2\text{MeSi}^+$ ; 56(1000),  $\text{C}_4\text{H}_8^+$ .

For D compound: 204, not obverved,  $\text{M}^+$ ; 177(10), M-Vi; 121 (290),  $(\text{MeO})\text{ViClSi}^+$ ; 113(620),  $(\text{MeO})\text{Vi}_2\text{Si}^+$ ; 56(1000),  $\text{C}_4\text{H}_8^+$ .

The  $^{29}\text{Si}$  nuclear magnetic resonance (NMR) had one major peak at 6.63 ppm relative to tetramethylsilane. The crude product was purified by short path distillation. The fraction boiling at 75°C. at 0.8 kPa (6 mmHg) weighed 28.22 g (58% yield) and was identified as compound B, methoxymethylvinyl(3-chloro-2-methylpropyl)silane.

Chloromethylvinyl(3-chloro-2-methylpropyl)silane was prepared as follows. A mixture of 28.00 g of compound B in 15.5 ml of acetyl chloride was allowed to sit at ambient temperature for 12 hours. A slight exotherm was noted. The low boiling material was removed by distillation and the product distilled at 88°C. to 90.5°C. and 4.0 kPa (30 mmHg) to give 25.2 g of material (88% yield). The product was chloromethylvinyl(3-chloro-2-methylpropyl)silane as was identified by  $^{13}\text{C}$  NMR: 134.79 and 134.73 and 134.68 (1:2:1, 1.67), SiVi; 52.93 (1.00),  $\text{CH}_2\text{Cl}$ ; 31.51 and 31.48 (0.83), CH; 22.88 and 22.84 (0.97),  $\text{CHMe}$ ; 20.13 and 20.10 (1.01),  $\text{SiCH}_2$ ; 0.59 and 0.54 (0.68), SiMe and by  $^{29}\text{Si}$  NMR: 17.81 and 17.78 (1:1) where data are presented as ppm (relative intensity).

55 Methylamine was condensed into a 1L round-bottom flask and distilled from sodium. To 490 ml of methylamine was slowly added 309.8 g of chloromethylvinyl(3-chloro-2-methylpropyl)silane, which resulted in two phases. The two phase system was transferred to a Parr reactor and heated at 110°C. and 1.59 MPa (230 psi) for 10 hours. The reaction mixture was cooled to -10°C., transferred to a 2 L round-bottom flask and 400 ml of

5 cold pentane was added. The layers were separated and the upper organic phase concentrated. After concentration, some ammonium salts had precipitated. These salts were removed by filtration and the product purified by distillation at reduced pressure to yield about 160 g (60% yield) of 1-aza-2-silacyclopentane with a small amount of ammonium salts. The distilled product was 97% pure 1,2,4-trimethyl-2-vinyl-1-aza-2-silacyclopentane with two major higher boiling impurities (about 1 wt% each) and numerous minor higher boiling impurities.

10 The GC-MS data were: 1,2,4-trimethyl-2-vinyl-1-aza-2-silacyclopentane, Retention Time 2.00 min; 155 (365), M<sup>+</sup>; 154 (243), M<sup>+</sup>-H; 140(97), M<sup>+</sup>-Me; 126 (113), M<sup>+</sup>-Vi; 113 (962, M<sup>+</sup>-C<sub>3</sub>H<sub>7</sub>; 112 (1000), M<sup>+</sup>-C<sub>3</sub>H<sub>7</sub>; 89 (396), Me-ViSiN=CH<sub>2</sub><sup>+</sup>; 71 (465) MeViSiH<sup>+</sup>. The <sup>13</sup>C NMR spectra was: 138.23 and 137.98, terminal vinyl; 132.86 and 137.98, internal vinyl; 62.19 and 61.92, N-CH<sub>2</sub>; 33.93 and 33.80, methine; 32.09 and 32.06, NMe; 21.48 and 21.54, CHMe; 21.23 and 20.95 Si-CH<sub>2</sub>; -3.43 and -4.29, SiMe. The <sup>29</sup>Si NMR had peaks at 6.229 and 6.039 relative to tetramethylsilane.

### SYNTHESIS 3

15 To 169 g of 1,1,3,3-tetramethyldisiloxane, 0.25 g of a chloroplatinic acid-1,3-divinyl-1,1,3,3-tetramethyldisiloxane complex having about 0.7 weight percent platinum and 17 g of 1-allyl-2,2,4-trimethyl-1-aza-2-silacyclopentane as prepared by Synthesis 1, at 80°C., were added into a 500 ml round-bottom flask fitted with a magnetic stirrer, condenser and addition funnel. 153.44 g of 1-allyl-2,2,4-trimethyl-1-aza-2-silacyclopentane was slowly added to the flask over a 35 minute period. The resulting reaction mixture was allowed to stir at 20 80°C. overnight and the product was isolated by distillation at reduced pressure. The portion boiling between 78°C. and 82°C. at 13.3 Pa (0.1 mm Hg) weighed 181 g and was identified as 1-(3-(2,2,4-trimethyl-1-aza-2-silacyclopentyl)propyl-1,1,3,3-tetramethyldisiloxane.

25 A mixture of the 20.67 g of 1-(3-(2,2,4-trimethyl-1-aza-2-silacyclopentyl)propyl-1,1,3,3-tetramethyldisiloxane, 10.6 g of vinyltrimethoxysilane which had been distilled from sodium and 0.03 g of a chloroplatinic acid-1,3-divinyl-1,1,3,3-tetramethyldisiloxane complex having about 0.7 weight percent platinum was heated for one hour at 120°C. The resulting product was distilled and the distillate was collected at 152°C. and 13.3 Pa (0.1 mm Hg). The amount of distillate collected was 28.2 g of 1-(3-(2,2,4-trimethyl-1-aza-2-silacyclopentyl)propyl-3-(2-trimethoxysilyl)ethyl)-1,1,3,3-tetramethyldisiloxane which was identified by <sup>13</sup>C and <sup>29</sup>Si NMR (nuclear magnetic resonance) and GC-MS.

30 SYNTHESIS 4

35 To 59.2 g of a 2:1 mole ratio of 1-(2-trimethoxysilyl)ethyl)-1,1,3,3-tetramethyldisiloxane and 1-(1-trimethoxysilyl)ethyl)-1,1,3,3-tetramethyldisiloxane and 32.8 g of 1,2,4-trimethyl-2-vinyl-1-aza-2-silacyclopentane as prepared by Synthesis 2 were added 0.07 g a chloroplatinic acid-1,3-divinyl-1,1,3,3-tetramethyldisiloxane complex having about 0.7 weight percent platinum. The resulting mixture was then heated for 2 hours at 160°C. and then distilled collecting the distillate coming off at 115°C. to 125°C. and 13.3 Pa (0.1 mm Hg). The amount of distillate collected was 86.0 g and was identified by <sup>13</sup>C and <sup>29</sup>Si NMR and GC-MS to be a mixture of 1-(2-(1,2,4-trimethyl-1-aza-2-silacyclopentyl)ethyl)-3-(2-trimethoxysilyl)ethyl)-1,1,3,3-tetramethyldisiloxane and 1-(2-(1,2,4-trimethyl-1-aza-2-silacyclopentyl)ethyl)-3-(1-trimethoxysilyl)ethyl)-1,1,3,3-tetramethyldisiloxane.

### EXAMPLE 1

45 A base was prepared by mixing in a dental mixer, 100 parts of silanol terminated polydimethylsiloxane having a viscosity of 0.05 m<sup>2</sup>/s and 1.35 parts of 1-(3-(2,2,4-trimethyl-1-aza-2-silacyclopentyl)propyl)-3-(2-trimethoxysilyl)ethyl)-1,1,3,3-tetramethyldisiloxane. This mixture was blended for 3 minutes and then 7 parts of methyltrimethoxysilane were added and mixed under vacuum. Then, 7.5 parts of fumed silica filler were added and mixed until a clear base was obtained. The resulting base was transferred to a storage tube, known as a SEMCO tube and centrifuged to deair the base. To the deaired base, 2 parts of bis-(ethoxyacetoxacetyl)diisopropoxy titanium (IV) were added and mixed for 3 minutes. The resulting sealant was centrifuged. Test specimens were cast at 22°C. and 50% relative humidity. The properties were measured and are shown in Table II. The surface of a test specimen was observed and the skin over time (SOT) was measured by observing the time from exposure to moisture until a finger lightly touched on the surface of the curing sealant was withdrawn without transfer of the sealant to the finger. The tack free time (TFT) was the time measured from the exposure of the sealant to moisture until a dry surface, free from tack was obtained. The durometer on the Shore A scale was measured according to ASTM Standard D-2240, the tensile strength at break in kiloPascals (kPa) and the elongation at break were measured according to ASTM Standard D-412.

EXAMPLE 2

5 A sealant was prepared as described in Example 1, except that 2.94 parts of 1-(3-(2,2,4-trimethyl-1-aza-2-silacyclopentyl)propyl)-3-(2-trimethoxysilyethyl)-1,1,3,3-tetramethyldisiloxane were used instead of the 1.35 parts of Example 1. The results are shown in Table II. The properties were measured as described in Example 1.

EXAMPLE 3

10 A sealant was prepared as described in Example 1, except that 2.95 parts of 1-(3-(2,2,4-trimethyl-1-aza-2-silacyclopentyl)propyl)-3-(2-trimethoxysilyethyl)-1,1,3,3-tetramethyldisiloxane were used instead of the 1.35 parts of Example 1 and 0.67 part of bis-(ethoxyacetoacetyl)diisopropoxy titanium (IV) was used instead of the 2 parts of Example 1. Test specimens were cast at 22°C. and 50% relative humidity and the properties were measured (Example 3). The sealant remaining in the tube was stored at 50°C. for 8 days prior to casting 15 test samples. After the heat aging test, specimens were cast at 22°C. and 50% relative humidity (Example 3A). The properties were measured as described in Example 1 and are shown in Table II.

EXAMPLE 4

20 A base was prepared by mixing in a dental mixer, 100 parts of silanol terminated polydimethylsiloxane having a viscosity of 0.05m<sup>2</sup>/s and 1.83 parts of 1-(3-(2,2,4-trimethyl-1-aza-2-silacyclopentyl)propyl)-3-(2-trimethoxysilyethyl)-1,1,3,3-tetramethyldisiloxane. This mixture was blended for 3 minutes and then 4 parts of methyltrimethoxysilane were added and mixed under vacuum. Then, 7.5 parts of fumed silica filler were added and mixed until a clear base was obtained. The resulting base was transferred to a SEMCO tube and centrifuged to deair 25 the base. To the deaired base, 0.25 part of bis-(ethoxyacetoacetyl)diisopropoxy titanium (IV) was added and mixed for 3 minutes. The resulting sealant was centrifuged. Test specimens were cast at 22°C. and 50% relative humidity. The properties were measured as described in Example 1 and are shown in Table II.

EXAMPLE 5

30 A base was prepared by mixing in a dental mixer, 100 parts of silanol terminated polydimethylsiloxane having a viscosity of 0.05 m<sup>2</sup>/s, 2.36 parts of 1-(3-(2,2,4-trimethyl-1-aza-2-silacyclopentyl)propyl)-3-(2-trimethoxysilyethyl)-1,1,3,3-tetramethyldisiloxane and 0.19 part of 1,2,2,4-tetramethyl-1-aza-2-silacyclopentane. This mixture was blended for 3 minutes and then 7 parts of methyltrimethoxysilane were added and mixed under 35 vacuum. Then, 7.5 parts of fumed silica filler were added and mixed until a clear base was obtained. The resulting base was transferred to a SEMCO tube, and centrifuged to deair the base. To the deaired base, 0.96 part of bis-(ethoxyacetoacetyl)diisopropoxy titanium (IV) was added and mixed for 3 minutes. The resulting sealant was centrifuged. Test specimens were cast at 22°C. and 50% relative humidity. The properties were measured as described in Example 1 and are shown in Table II.

40

TABLE II

EXAMPLE	SOT minutes	TFT minutes	Durometer Shore A	Tensile Strength kPa	Elongation percent	Modulus 100% kPa
1	1	7	26	931	196	524
2	3	6	32	1551	283	614
3	7	16	23	662	124	607
3A	11	26	26	1110	223	593
4	16	20	27	1186	259	448
5	10	15	18	793	239	352

55

EXAMPLE 6

5 A base was prepared by mixing in a dental mixer, 100 parts of silanol terminated polydimethylsiloxane having a viscosity of 0.05 m<sup>2</sup>/s and 2.00 parts of a mixture in which the amounts were such that there were 2 moles of 1-(2-(1,2,4-trimethyl-1-aza-2-silacyclopentyl)ethyl)-3-(2-trimethoxysilyl)ethyl)-1,1,3,3-tetramethyldisiloxane and 1 mole of 1-(2-(1,2,4-trimethyl-1-aza-2-silacyclopentyl)ethyl)-3-(1-trimethoxysilyl)ethyl)-1,1,3,3-tetramethyldisiloxane. This mixture was blended for 3 minutes and then 4 parts of methyltrimethoxysilane were added and mixed under vacuum. Then, 7.5 parts of fumed silica filler were added and mixed until a clear base was obtained. The resulting base was transferred to a SEMCO tube and centrifuged to deair the base. To the deaired base, 1.9 parts of bis(ethoxyacetoacetyl)diisopropoxy titanium (IV) were added and mixed for 3 minutes. The resulting sealant was centrifuged. Test specimens were cast at 22°C. and 50% relative humidity. The properties were measured as described in Example 1 and are shown in Table III.

EXAMPLE 7

15 20 A sealant was prepared as described in Example 6, except that 0.5 part of bis(ethoxyacetoacetyl)diisopropoxy titanium (IV) was used instead of the 1.9 parts of Example 6. Test specimens were cast at 22°C. and 50% relative humidity and the properties were measured as described in Example 1. The results are shown in Table III.

EXAMPLE 8

25 30 A base was prepared by mixing in a dental mixer, 100 parts of silanol terminated polydimethylsiloxane having a viscosity of 0.05 m<sup>2</sup>/s and 1.4 parts of a mixture in which the amounts were such that there were 2 moles of 1-(2-(1,2,4-trimethyl-1-aza-2-silacyclopentyl)ethyl)-3-(2-trimethoxysilyl)ethyl)-1,1,3,3-tetramethyldisiloxane and 1 mole of 1-(2-(1,2,4-trimethyl-1-aza-2-silacyclopentyl)ethyl)-3-(1-trimethoxysilyl)ethyl)-1,1,3,3-tetramethyldisiloxane. This mixture was blended for 3 minutes and then 4 parts of methyltrimethoxysilane were added and mixed under vacuum. Then, 8.4 parts of fumed silica filler were added and mixed until a clear base was obtained. The resulting base was transferred to a SEMCO tube and centrifuged to deair the base. To the deaired base, 1.5 parts of bis(ethoxyacetoacetyl)diisopropoxy titanium (IV) were added and mixed for 3 minutes. The resulting sealant was centrifuged. Test specimens were cast at 22°C. and 50% relative humidity (Example 8). The properties were measured as described in Example 1 and are shown in Table III. The sealant remaining in the tube was stored at 50°C. for 14 days prior to casting test samples. After the heat aging, test specimens were cast at 22°C. and 50% relative humidity (Example 8A). The results are shown in Table III. The properties were measured as described in Example 1.

EXAMPLE 9

40 45 A base was prepared by mixing in a dental mixer, 100 parts of silanol terminated polydimethylsiloxane having a viscosity of 0.05 m<sup>2</sup>/s and 2.85 parts of a mixture in which the amounts were such that there were 2 moles of 1-(2-(1,2,4-trimethyl-1-aza-2-silacyclopentyl)ethyl)-3-(2-trimethoxysilyl)ethyl)-1,1,3,3-tetramethyldisiloxane and 1 mole of 1-(2-(1,2,4-trimethyl-1-aza-2-silacyclopentyl)ethyl)-3-(1-trimethoxysilyl)ethyl)-1,1,3,3-tetramethyldisiloxane. This mixture was blended for 3 minutes and then 4 parts of methyltrimethoxysilane were added and mixed under vacuum. Then, 9 parts of fumed silica filler were added and mixed until a clear base was obtained. The resulting base was transferred to a SEMCO tube and centrifuged to deair the base. To the deaired base, 2 parts of bis(ethoxyacetoacetyl)diisopropoxy titanium (IV) were added and mixed for 3 minutes. The resulting sealant was centrifuged. Test specimens were cast at 22°C. and 50% relative humidity. The properties were measured as described in Example 1 and are shown in Table III.

EXAMPLE 10

50 55 A base was prepared by mixing in a dental mixer, 100 parts of silanol terminated polydimethylsiloxane having a viscosity of 0.05 m<sup>2</sup>/s and 2.00 parts of a mixture in which the amounts were such that there were 2 moles of 1-(2-(1,2,4-trimethyl-1-aza-2-silacyclopentyl)ethyl)-3-(2-trimethoxysilyl)ethyl)-1,1,3,3-tetramethyldisiloxane and 1 mole of 1-(2-(1,2,4-trimethyl-1-aza-2-silacyclopentyl)ethyl)-3-(1-trimethoxysilyl)ethyl)-1,1,3,3-tetramethyldisiloxane. This mixture was blended for 3 minutes and then 7 parts of methyltrimethoxysilane were added and mixed under vacuum. Then, 9 parts of fumed silica filler were added and mixed until a clear base was obtained. The resulting base was transferred to a SEMCO tube and centrifuged to deair the base. To the

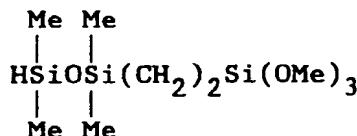
desired base, 1.5 parts of bis(ethoxyacetocetyl)diisopropoxy titanium (IV) were added and mixed for 3 minutes. The resulting sealant was centrifuged. Test specimens were cast at 22°C. and 50% relative humidity. The properties were measured as described in Example 1 and are shown in Table III.

TABLE III

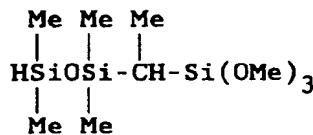
EXAMPLE	SOT minutes	TFT minutes	Durometer Shore A	Tensile Strength kPa	Elongation percent	Modulus 100% kPa
6	7	18	30	972	177	627
7	>150	NA	22	524	117	476
8	5	6	26	758	146	572
8A	—	---	12	883	294	283
9	3	4	32	779	134	627
10	12	41	31	2461	331	669

#### COMPARISON EXAMPLE 1

To a 3-necked flask fitted with an air stirrer, condenser, thermometer and positive nitrogen pressure, there were added 1340 g of  $(Me_2HSi)_2O$ , 740 g of  $ViSi(OMe)_3$  and 40 drops of chloroplatinic acid complex of divinyltetramethylsiloxane diluted with dimethylvinylsiloxy endblocked polydimethylsiloxane to provide 0.7 weight percent platinum. The material was then heated to 60°C. for approximately 5 hours and then stripped of excess  $(Me_2HSi)_2O$ . The yield was 1362 g of product which was a mixture having a molar ratio of two moles of the formula

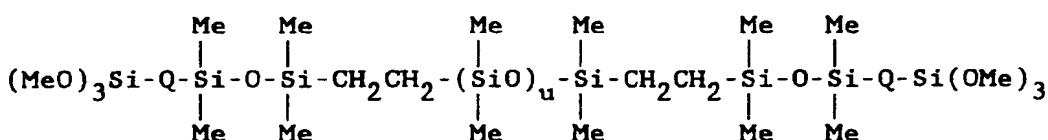


and one mole of the formula



for use as an endcapper.

A polydimethylsiloxane endblocked with dimethylvinylsiloxy groups and having a viscosity of 0.05 m<sup>2</sup>/s was reacted with the above endcapper in the presence of platinum catalyst. A polymer was obtained as described by the following general average formula



in which Q had a molar ratio of 2 moles of  $-\text{CH}_2\text{CH}_2-$  and one mole of  $-\text{CH}(\text{Me})-$  and u had a value of about

840.

To 100 parts by weight of the above polymer were mixed in a dental mixer 9 parts of fume silica. This base was placed under a vacuum to remove the entrapped air and was then placed in a SEMCO tube. While in the tubes, there were added 7 parts  $\text{MeSi}(\text{OMe})_3$  and 2 parts of bis-(ethoxyacetoacetyl)diisopropoxy titanium (IV). After mixing for 3 minutes and then centrifuging, test specimens of the sealant composition were cast at 23°C. and 50% relative humidity. One of the tubes was stored for 8 days at 50°C. (COMPARISON EXAMPLE 1A) and then the properties were measured as described in Example 1. The results observed are shown in Table IV.

TABLE IV

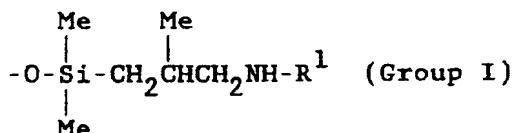
COMPARISON EX	SOT minutes	TFT minutes	Durometer Shore A	Tensile Strength kPa	Elongation percent	Modulus 100% kPa
1	25	86	27	1524	230	655
1A	21	57	---	---	---	---

20 **Claims**

1. A polydiorganosiloxane comprising an alkoxy endblocked polydiorganosiloxane of the following general formula

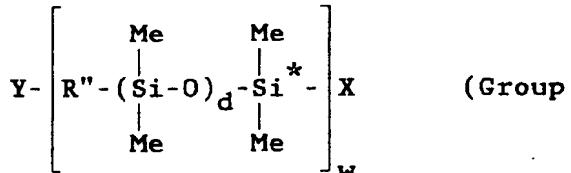


25 where Z is

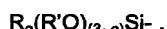


35 or

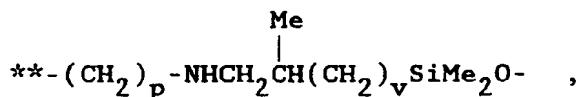
40 II)



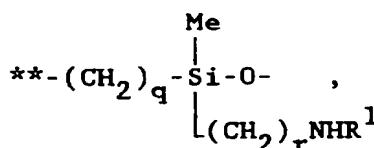
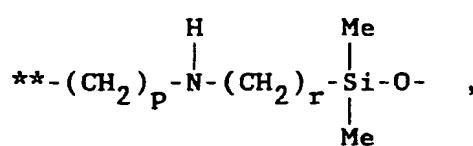
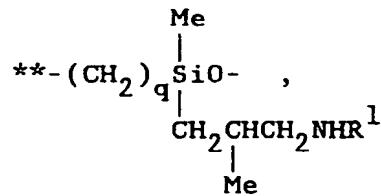
45 where Y is



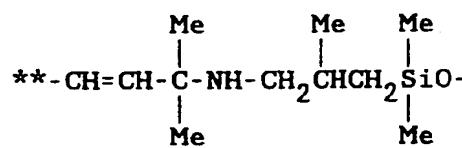
46 X is



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or



in which a is 0 or 1, d has a value of 1 to 3 inclusive, v is 0 or 1, n has a value of at least 8, p has a value of 3 to 6 inclusive, q has a value of 2 to 6 inclusive, r has a value of 4 to 6 inclusive, w is 0 or 1, Me is methyl radical, R<sup>1</sup> is an alkyl radical having from 1 to 6 inclusive carbon atoms, each R is a monovalent radical independently selected from the group consisting of hydrocarbon radicals and halogenated hydrocarbon radicals, R' is an alkyl radical of 1 to 3 inclusive carbon atoms, R" is a divalent hydrocarbon radical selected from the group consisting of -(CH<sub>2</sub>)<sub>b</sub>- and -CH(Me)(CH<sub>2</sub>)<sub>c</sub>- , b is from 2 to 6 inclusive, c is from 0 to 4 inclusive and the bond at \*\* is attached to the silicon atom Si<sup>+</sup> and in which at least one Z is of the Group II formula.

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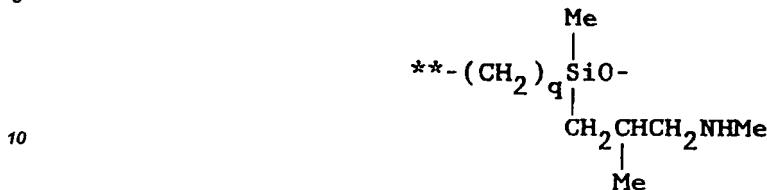
2. The polydiorganosiloxane in accordance with claim 1 in which n has a value of from 50 to 1,000.
3. A polydiorganosiloxane mixture comprising a mixture of two types of polydiorganosiloxanes in accordance with claim 1 in which Type 1 is a polydiorganosiloxane in which both Z are Group I and Type 2 is a polydiorganosiloxane in which one Z is Group I and one Z is Group II and further comprising a Type 3 polydiorganosiloxane in which both Z are Group I.
4. The polydiorganosiloxane in accordance with claims 1-3 in which R and R' are methyl radicals.
5. The polydiorganosiloxane in accordance with claim 4 in which R" is a mixture of -CH<sub>2</sub>CH<sub>2</sub>- and -CH(Me)-
- 50
6. The polydiorganosiloxane in accordance with claim 4 in which X is



a is 0 and p is 3.

7. The polydiorganosiloxane in accordance with claim 4 in which X is

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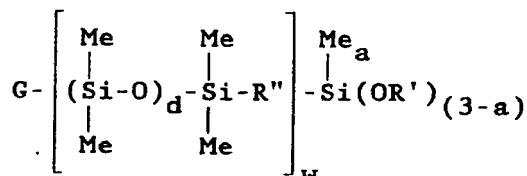


a is 0 and q is 2.

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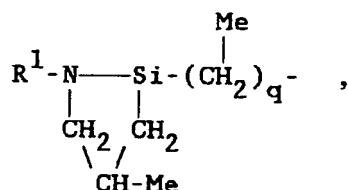
8. A method of preparing alkoxy endblocked polydialkylsiloxanes comprising mixing an azasilacycloalkyl functional alkoxy silane selected from the group consisting of

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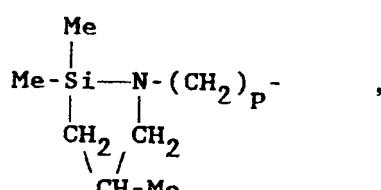


in which G is an azasilacycloalkyl group selected from the group consisting of

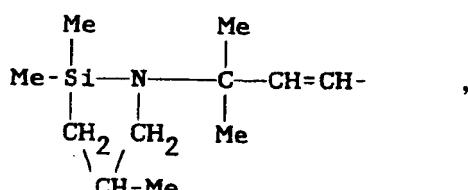
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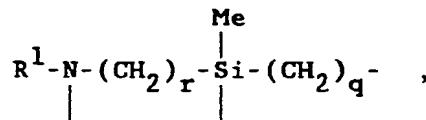
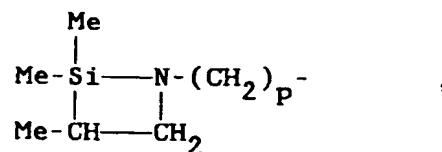
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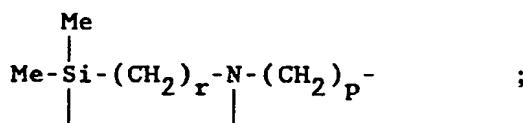
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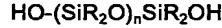


and



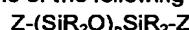
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in which  $\text{R}^1$  is an alkyl radical having from 1 to 6 inclusive carbon atoms,  $\text{R}'$  is an alkyl radical of from 1 to 3 carbon atoms,  $\text{R}''$  is a divalent hydrocarbon radical selected from the group consisting of  $-(\text{CH}_2)_b-$  and  $-\text{CH}(\text{Me})(\text{CH}_2)_c-$ ,  $b$  is from 2 to 6 inclusive,  $c$  is from 0 to 4 inclusive,  $\text{Me}$  is methyl radical,  $a$  is 0 or 1,  $d$  has a value of 1 to 3 inclusive,  $w$  is 0 or 1,  $p$  has a value of 3 to 6 inclusive,  $q$  has a value of 2 to 6 inclusive and  $r$  has a value of 4 to 6 inclusive with a silanol terminated polydiorganosiloxane of the general formula



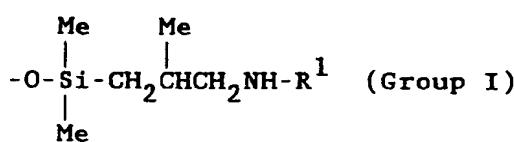
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where each  $\text{R}$  is a monovalent hydrocarbon radical independently selected from the group consisting of hydrocarbon radicals and halogenated hydrocarbon radicals and  $n$  has a value of at least 8 and the aza-silacycloalkyl functional aloxysilane reacts with the silanol terminated polydiorganosiloxane producing an alkoxy endblocked polydiorganosiloxane of the following general formula



where  $\text{Z}$  is

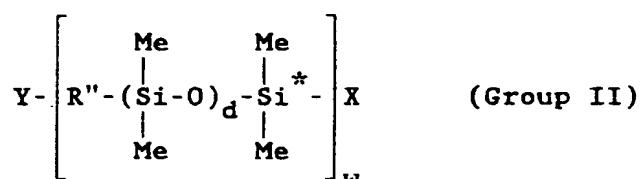
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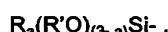
or

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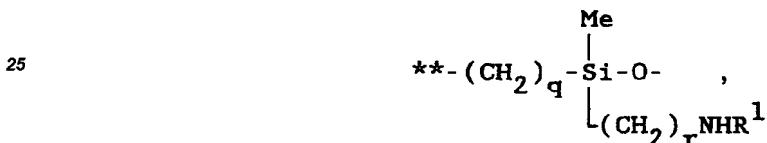
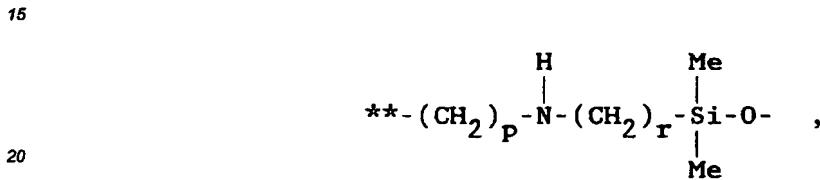
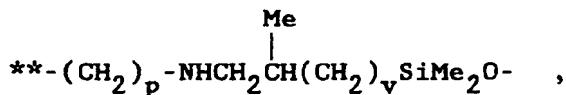
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where  $\text{Y}$  is

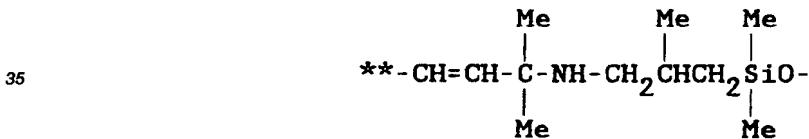


$\text{X}$  is

55



30      or



40      in which a is 0 or 1, d has a value of 1 to 3 inclusive, y is 0 or 1, n has a value of at least 8, p has a value of 3 to 6 inclusive, q has a value of 2 to 6 inclusive, r has a value of 4 to 6 inclusive, w is 0 or 1, Me is methyl radical, R<sup>1</sup> is an alkyl radical having from 1 to 6 inclusive carbon atoms, each R is a monovalent radical independently selected from the group consisting of hydrocarbon radicals and halogenated hydrocarbon radicals, R' is an alkyl radical of 1 to 3 inclusive carbon atoms, R" is a divalent hydrocarbon radical selected from the group consisting of -(CH<sub>2</sub>)<sub>b</sub>- and -CH(Me)(CH<sub>2</sub>)<sub>c</sub>- , b is from 2 to 6 inclusive, c is from 0 to 4 inclusive and the bond at \*\* is attached to the silicon atom Si\* and in which at least one Z is of the Group II formula.

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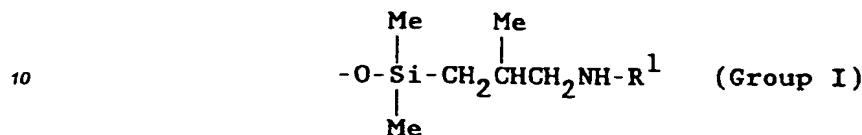
9. The method according to claim 8 in which n has a value of from 50 to 1,000.
- 50 10. The method according to claim 9 further comprising mixing with the azasilacyclopentyl functional alkoxysilane and silanol terminated polydiorganosiloxane, 1,2,2,4-tetramethyl-1-aza-2-silacyclopentane.
11. The method according to claims 8-10 in which R and R' are methyl radicals.
- 55 12. The method according to claim 11 in which R" is a mixture of -CH<sub>2</sub>CH<sub>2</sub>- and -CH(Me)-.
13. The method according to claim 11 in which a is 0 and p is 3.
14. The method according to claim 11 in which a is 0 and q is 2.

15. A one package room temperature vulcanizable silicone elastomer comprising a product which is storage stable in the absence of moisture and curable to an elastomeric product when exposed to moisture and obtained by mixing

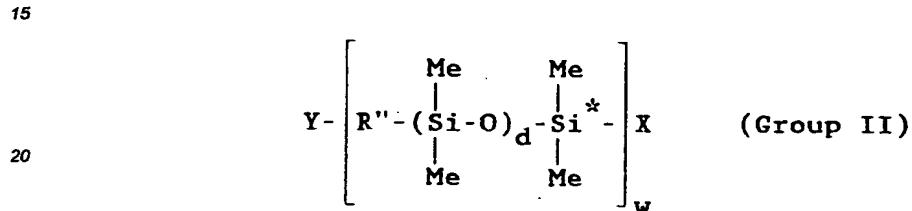
5 (A) an alkoxy endblocked polydiorganosiloxane of the following general formula



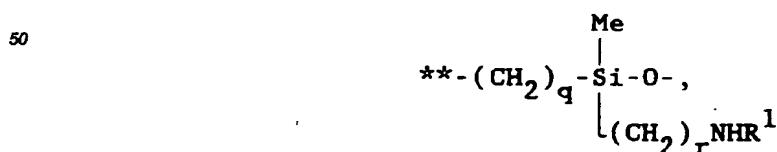
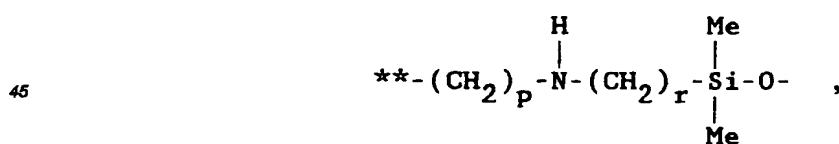
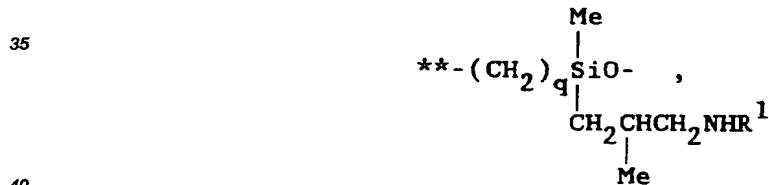
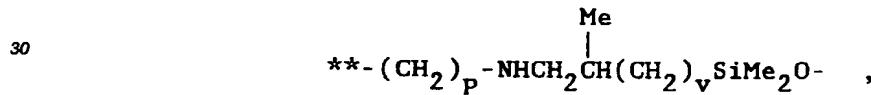
where  $Z$  is



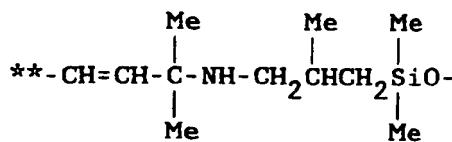
15 or



where  $Y$  is



55 or



in which  $\underline{a}$  is 0 or 1,  $\underline{d}$  has a value of 1 to 3 inclusive,  $\underline{y}$  is 0 or 1,  $\underline{n}$  has a value of at least 8,  $\underline{p}$  has a value of 3 to 6 inclusive,  $\underline{q}$  has a value of 2 to 6 inclusive,  $\underline{r}$  has a value of 4 to 6 inclusive,  $\underline{w}$  is 0 or 1, Me is methyl radical,  $\text{R}'$  is an alkyl radical having from 1 to 6 inclusive carbon atoms, each  $\text{R}$  is a monovalent radical independently selected from the group consisting of hydrocarbon radicals and halogenated hydrocarbon radicals,  $\text{R}'$  is an alkyl radical of 1 to 3 inclusive carbon atoms,  $\text{R}''$  is a divalent hydrocarbon radical selected from the group consisting of  $-(\text{CH}_2)_b-$  and  $-\text{CH}(\text{Me})(\text{CH}_2)_c-$ ,  $b$  is from 2 to 6 inclusive,  $c$  is from 0 to 4 inclusive, the bond at  $**$  is attached to the silicon atom  $\text{Si}^*$  and in the alkoxy endblocked polydiorganosiloxane at least one  $\text{Z}$  is Group II,  
 (B) an alkoxy silane,  
 (C) a titanium catalyst, and  
 (D) a filler.

20 16. The one package room temperature vulcanizable silicone elastomer in accordance with claim 15 in which  $\underline{n}$  has a value of from 50 to 1000.

17. The one package room temperature vulcanizable silicone elastomer in accordance with claim 15 in which  $\text{R}$  and  $\text{R}'$  are methyl radicals.

25 18. The one package room temperature vulcanizable silicone elastomer in accordance with claims 15-17 in which  $\text{R}''$  is a mixture of  $-\text{CH}_2\text{CH}_2-$  and  $-\text{CH}(\text{Me})-$ .

19. The one package room temperature vulcanizable silicone elastomer in accordance with claim 18 in which  $\text{X}$  is

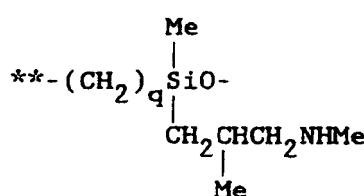
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35  $\underline{a}$  is 0 and  $\underline{p}$  is 3.

20. The one package room temperature vulcanizable silicone elastomer in accordance with claim 18 in which  $\text{X}$  is

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50  $\underline{a}$  is 0 and  $\underline{q}$  is 2.

21. The one package room temperature vulcanizable silicone elastomer in accordance with claim 20 in which the alkoxy silane of (B) has a formula  $\text{R}_x\text{Si}(\text{OR}')_{4-x}$  where  $\underline{x}$  is 0 or 1 and where  $\text{R}$  and  $\text{R}'$  have the same meaning as in claim 15.

55 22. The one package room temperature vulcanizable silicone elastomer in accordance with claim 21 in which  $\text{R}$  and  $\text{R}'$  are methyl radicals and  $\underline{x}$  is 1.

23. The one package room temperature vulcanizable silicone elastomer in accordance with claim 22 in which

the titanium catalyst of (C) is a dicarbonyl titanium compound.

**24. The one package room temperature vulcanizable silicone elastomer in accordance with claim 18 in which the alkoxy silane of (B) is methyltrimethoxysilane.**

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